# Introduction to fisheries management

## advantages, difficulties and mechanisms

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# Introduction to fisheries management

## advantages, difficulties and mechanisms

by
**J-P. Troadec**
Fishery Policy and Planning Division
Fishery Development Planning Service

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## Preparation of this document

The extension of national jurisdiction gives coastal states the possibility of gradually eliminating the economic waste and overfishing that inevitably occurs when access to resources is uncontrolled. In the future, more attention should be paid to identifying and analysing national contexts and to executing development plans more in keeping with specific national interests.

To assist administrators and those responsible for the development of national fisheries, the FAO Fishery Policy and Planning Division has decided to prepare a series of technical papers on Fisheries Management Methods.

The present document reviews and expands in further detail a paper presented at the Workshop on the management of national fishery development plans organized by the Sea Fish Industry Authority at Hull (Great Britain) in July 1981.

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ABSTRACT

The introduction is a reminder that the extension of national jurisdiction over world fisheries has three major consequences: the immediate transfer of the production of deep sea fleets to control by coastal states, the possibility of reducing economic waste and overfishing which are the inevitable results if competition for resources is not regulated, and a shift of approach to pay more attention to specific local conditions and perspectives, and national fisheries development methods in the past.

The first section reviews the consequences, at the biological, economic and social levels, resulting from two fundamental aspects of fishery resources:

(a) because of their natural and biological character their output is limited: the maximum catch level can only be attained and maintained if the total number and composition (size and species) of catches are kept within certain limits; and

(b) their mobility makes their exploitation by the private sector difficult, if not impossible; consequently, without the intervention of a central authority and the emergence of a consensus, the fishermen are drawn into fierce competition which is ultimately harmful to the profitability of the exploitation as a whole.

It shows that the different benefits (economic, social, nutritional, recreational, etc.) which fishery can produce are not usually compatible since they correspond to different levels of fishing. For good fisheries management it is essential therefore, that the objectives sought and their order of priority be clearly defined.

The second section analyses the main methods that can be contemplated to maintain fishing at the level corresponding to the objective selected: limitation of catches, limitation of fishing effort or, better, means of capture, distribution of the stock itself among the fishermen, and taxation. Their respective advantages can be compared by reference to three basic criteria: conservation of the resource at a high level of production; reduction of the resulting superfluous costs so as to maximize net profits, and easing the application of schemes by involving fishermen in the rationalization of their exploitation.

The final section deals with the question of the distribution among fishermen of the wealth derived from the fishery. The importance of regular access to fisheries, and hence to sharing the profits, stems directly from the need to control the exploitation level. Aspects of this question are analysed successively at the national, and then the international (shared stocks) level. The segregation of fishing activities by exclusive economic zones, as well as a different distribution of the activities of fleets within areas under national jurisdiction, changes the terms of their competition and expands their scope; the keenness and character of such competition depends on the various stock distribution, mixture and migration patterns.

The paper concludes that under the old system of open competition it was very difficult for countries to go beyond mere conservation of resources. In fact, at least in the international fisheries, the countries' catch capacity was the chief instrument by which they could hope to preserve their rights over the resource. The influence of international fisheries on management practices can explain why the principles of free access and non-intervention of state authorities to control access to resources should have prevailed so frequently in the management of national fisheries. The extension of national jurisdiction now enables countries to consider the generalization of new fisheries development and management strategies and methods.

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## 1. INTRODUCTION

Most countries, whether they be traditional fishing powers or countries rich in resources, have now accepted a new common law redefining the main principles of access to exploitation of ocean fishery resources. This basic change in the legal framework of world fisheries has already had, or could have, three major consequences for the future of world fisheries:

(a) in the short term, the new conditions of participation in fisheries, now based on geographic criteria, have led to transfers of output involving a considerable part of the world catch;

(b) in the long term, the individual authority acquired by the coastal countries gives them the possibility to gradually reduce the waste of economic and social benefits which was practically inevitable under the previous regime of free access to resources and the resulting fierce competition;

(c) lastly, the decline of long range fleet fisheries should accelerate the revision of the development models which have predominated in the past: greater attention should be paid to the adoption of exploitation patterns more suited to specific national contexts and interests, especially in the developing countries.

Up to now we have mostly been aware of the immediate effects. There has, for example, been much discussion on the topic of who were the main beneficiaries and losers under the new regime. F. Christy (FAO, 1981c) has analysed these consequences starting from an estimate of the economic value of the catch taken by the long range fleets, before the effects of the new regime began to make themselves felt (Table 1). These catches then represented more than a quarter of world production. The concentration of the fishing fleets in the rich fishing areas (found mainly, but not only, in the cold temperate seas), meant that, taken overall, the developed countries (Canada, United States, Iceland, Norway, etc.) benefitted directly much more than the developing countries (except for those countries situated on the North and South Western coasts of Africa, Argentina and Uruguay, etc.) from the change of regime. But, the dominance of the developed countries (Japan, USSR and East European countries) in the operation of long range fleets has meant that it is they who have absorbed almost all the negative impact, as the foreign catch of developing countries (Korea, Cuba, Ghana, Thailand) represents only a very small portion of the total value of the catch of long range fleets.

This comparison is based on the 1972 statistics, the last year before the effects of the new regime began to be felt. It is hard to imagine what might have been the subsequent evolution of the role of long-range fleets. Certainly the increased cost of energy would have hindered the expansion of their activity in the ocean regions where fish are less abundant. On the other hand it does not seem that this would have halted the geographic spread, in other forms, of fishing by the traditional fishing powers. The transition might have been made through the creation by these countries of local fleets. Their higher efficiency would probably have represented a considerable advantage in the competition for resources which were still mostly freely acessible.

Table 1

Estimated value of catches, excluding tuna[a/], made in 1972 by long range fishing fleets before the effects of the change in the law of the sea were felt (estimate taken from FAO, 1981c

| | Million Dollars USA | Percentage of world catch |
|---|---|---|
| Value of catches by long distance fleets | 5 560 | 25 |
| - taken in front of the developed countries | 3 700 | 17 |
| - taken in front of the developing countries | 1 860 | 8 |
| - by the developed countries | 5 460 | 25 |
| - by the developing countries | 100 | - |

a/ We should add the unknown, but substantial, catches (1.2 million dollars) made by the long distance tuna fleets in the EEZs of other countries

However, these transfers of output do not accurately reflect the economic gains or losses already or potentially made or suffered by the countries concerned. On one hand, because of the management shortcomings brought about by particularly intense competition in international fisheries, the net profits from fishery have so far been only marginally positive at best. On the other hand, several countries which have acquired control over resources larger than their own consumption are already deriving considerable advantages from the new regime, either as cash in the form of royalties or in kind in that of investments, equipment, aid, etc., or of a political character.

Yet if the immediate effects of the new law of the sea on the activities of deep sea fleets have not been felt equally, most coastal countries[1/] now have the possibility of deriving higher social and economic benefits from the fisheries over which they have control. The extension of national jurisdictions can make it possible, through exercise of this new authority, to control access to resources that are naturally limited. Therefore, the tendency to dissipation of net benefits and to biological over-exploitation caused by free competition should gradually be reversed.

At the same time, the decline of international fisheries whose characteristics and prospects had dominated development and management practices during recent decades should encourage recourse to development and exploitation models more suited to the needs, advantages, and interests of each country. In fact, a study of past strategies shows that the expansion model of industrial fisheries in the advanced countries has generally been transposed in the Third World countries without taking sufficient account of the species features of the latter (abundant labour, scarce capital, undeveloped markets, etc.), or the constraints which have come to influence the prospects for expansion of fisheries (increased cost of energy, growing scarcity of resources which are easy to develop) (Troadec, in preparation).

In order for fisheries to contribute better to national economic development it is necessary to appreciate the particular aspects of fishing and the conditions which the nature of fishery resources itself imposes on their full development. Ocean fishery is concerned mainly with stocks which are a part of natural ecosystems whose output man cannot improve except in highly specialized and geographically limited (extensive aquaculture) cases. At best he can fish the net surplus of the output, whose limit can only be approached if he manages to attain and keep the tonnages captured and, to a lesser extent, the structure (age and species) of the catch within certain limits. Secondly, the mobility of many fishery resources makes it impossible in practice to turn their exploitation over to the private sector, assigning pre-established shares of the resource to each

1/ Independently of the reconversion problems raised by the reduction of long distance fleets among the major world fishing powers (countries of Eastern Europe, Korea, Japan, Thailand, etc.)

operator. This feature places the operators in a position of open and permanent competition to acquire the net economic yield derived from their activity. If this competition cannot be controlled it leads, first of all, to overinvestment and thereby to the gradual dissipation of net benefits and then, eventually, to biological overexploitation of the resources.

This document proposes to review this internal dynamic of fisheries, analyse the conditions that might lead to coherent exploitation, i.e., one adapted to the objectives set for the development of the resource, and to see, within the new legal context, what types of regulations would be best suited to build up and maintain fisheries in conditions corresponding to those objectives.

## 2. NATURE OF THE PROBLEM[1/]

### 2.1 Basic Concepts

These concepts can be described by taking the simple example of a single fishery consisting of only one species exploited by one group of fishermen using the same fishing method. This rather oversimplified situation does not allow adequately for the diversity of cases encountered in practice; on the other hand, it affords a firm grasp of the internal dynamic of fisheries and the bases underlying the importance and problems of their management. The concepts that emerge are classic. They can therefore be reviewed quickly. Nevertheless, consideration of them, especially in formulating development plans, is by no means the rule; that is one of the reasons why all too often these programmes do not achieve the expected results.

#### 2.1.1 Biological aspects

The classic stock assessment models (Schaefer, 1954 and 1957; Beverton and Holt, 1957; Ricker, 1958) describe the evolution, in a fishery of this type, of the total catch and yield (catch per unit of effort) in terms of fishing effort (Figure 1). The value of analysis of responses of the fishery to variations of fishing effort lies in the fact that this factor is the chief parameter of exploitation which can be directly controlled by man, and through it the latter can have the best expectation of influencing the state of the stock and its productivity.

When the rate of exploitation increases in a fishery, we see that at first there is an almost proportionate increase in total catches. Then this growth rate drops in steadily and the curve finally shows a maximum level (maximum sustainable yield or MSY)[2/] which marks the upper limit of the stock's production. Beyond this maximum the average yield tends to drop fairly quickly.

Maximum production, in this definition, was for a long time the sole objective for fisheries management. Its success can be explained by the simplicity of the model on which it is based, which did much to convince administrators of the need to limit fishing if they wished to maintain yields at a high level. In international fisheries where the various national authorities each had to defend the rival interests if their fishermen and their respective fishing industries, and tried to obtain for them the most advantageous catch quotas (or in any case, the least reduced), the MSY was the option involving the least reduction in catches and catch methods in a fishery that was already being overexploited.

The yield curve (catch per unit of effort or cpue), for its part, drops steadily when a stock starts to be exploited. If this characteristic is not duly considered when a resource is being developed it inevitably leads to an overoptimistic forecast of the productivity, and therefore of the profitability, of the new catch methods contemplated.

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1/ This section is based on a course already published (Troadec, 1980)

2/ Maximum Sustainable Yield

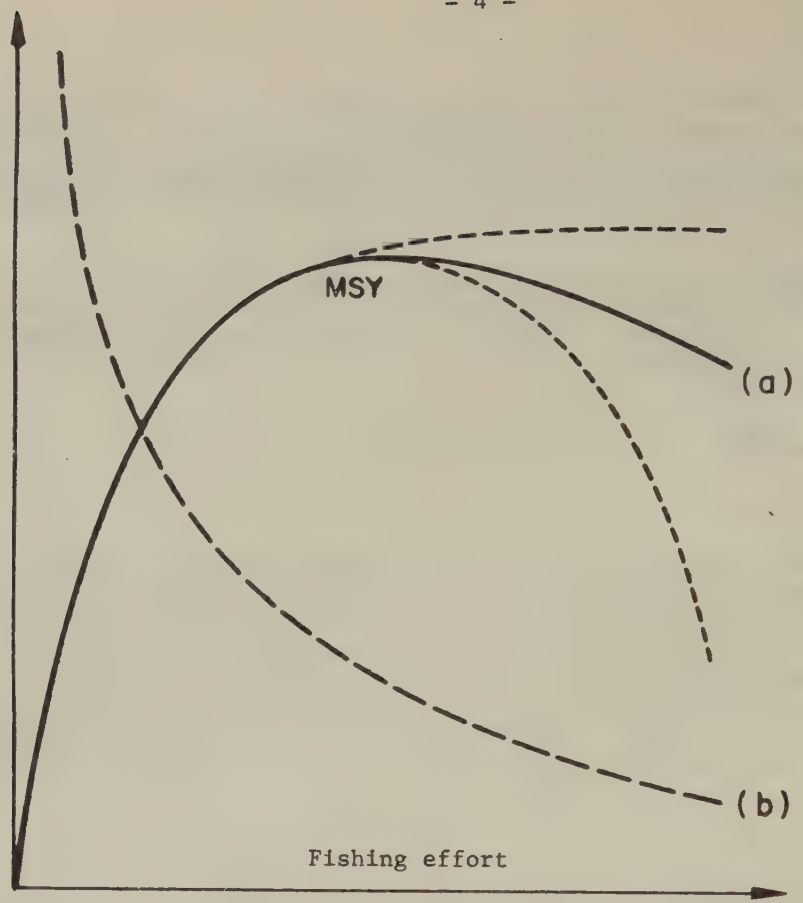


Figure 1 Fishery consisting of one species, a single method of fishing and a single community of fishermen: yield (a) on the one hand, catch and size of stock (b) on the other hand, in relation to fishing rate (or fishing effort)

The two curves (a and b, Figure 1) can be shifted within moderate limits, towards higher or lower values by changing the age structure of the catch (Figure 8). Thus one can get higher yields for greater fishing efforts by increasing the average age of the first catch. This can be achieved, for example, by increasing the size of the mesh of the trawl; in this way, by letting young individuals escape one can later capture a part whose total weight will be greater than the total weight of those that were allowed to escape by enlarging the mesh. This is the second and the only other factor on which man can act directly to improve the exploitation rate of natural fish stocks (see Section 3.1).

The yield curve also represents the evolution of the stock's biomass when fishing is intensified, since the cpue, insofar as they have been measured accurately, are in proportion to that biomass. At moderate fishing levels, it has been found that the reduction of the biomass resulting from intensification of fishing does not substantially affect the stock's capacity to reproduce. The theory shows, and it is confirmed by the history of fisheries, that fish stocks are capable of supporting sizable removals during long periods. At moderate levels of exploitation, one can even see a rise of average recruitment as a reaction by which the stock tends to compensate the drop in abundance resulting from its exploitation. This compensatory mechanism operates mainly at the egg and larvae stage. Every year fish spawn a large number of eggs. The number of these which will survive until the beginning of the exploitation phase is minimal and will depend much more on the environmental conditions they will experience during their larva phase and the environment's biotic capacity than on the number of eggs originally spawned, and therefore on the size of the producer stock. In fact, contrary to what laymen believe, for a long time it was thought that in most species the recruitment level was largely independent of the size of the parent stock, and that therefore it was useless to try to improve their recruitment, and hence the production it occasioned, by protecting the breeders or their spawn.

This observation, which is a fundamental of the dynamics of fish populations, explains why it is important to preserve recruits after they have passed the critical phase of their lives as larvae. Since they are no longer protected by any compensatory mechanism, the average age of first catch and the exploitation rate to which all the recruits spawned by

the stock each year are suspected, should then be adjusted so as to derive from them the optimum of what they can produce throughout their fished phase.

In fact, it has been noted that with high intensification in the exploitation of various stocks there is a chronic and sometimes sharp drop in recruitment, even if it is difficult to establish the ratio between the parent stock and recruitment because of the dispersal of data (caused by the variability of the environment and its effects on recruitment) and the shortness of the data series available for most fisheries. This chronic drop in recruitment is felt particularly when the fishing exceeds the MSY. Indeed, it has been demonstrated that beyond this maximum the speed of the decline in catches reflects to a great extent the form of the stock recruitment curve for the lower stock levels, i.e., the chronic drop in recruitment following overfishing of the parent stock (Laurec, 1977). In practice, conservation of a sufficient parent stock to maintain recruitment at a high level will be achieved by control of the fishing rate to which the whole stock is subject rather than by temporary, and therefore too brief, protection of spawners immediately before and during spawning.

The models on which the production and yield curves are based take as their initial hypothesis that the environment is invariable. Actually, each yearly observation deviates more or less markedly from these averages curves depending in particular, on the changes in the environment and their effects on recruitment. When these natural variations are random they do not affect either the height nor the shape of the curves. But this is not the case when the environment shows long-term evolutions. Several fisheries have been established (haddock of Bank George, for example) thanks to natural but temporary increases of the stock, which can occur side by side with colonization or expansion of the stock's distribution area (extension of Moroccan sardine to the south). Consequently, as long as stock assessments are based on short historical data series, the longer the term of the forecasts the higher will be the risk of error.

It has also been frequently observed that the interannual variability in the biomass of the stock, and hence of yields, increases with intensification of the fishing rate. This can be explained by a lowering of the average life expectancy of cohorts and, therefore, a reduction in the number of those which actually contribute most each year to the catches. Thus, the same variability and recruitment will be felt all the more when it affects a stock composed of a small number of age classes.

It is difficult to determine the influence of the various factors, both natural and those caused by fishing, which could have operated in the collapse of many fisheries in recent years. Such factors include the effects of long term climatic fluctuations on the geographic distribution of resources and the biotic capacity of the environment, the natural variability of stocks which is often higher with coastal pelagic species, a drop in recruitment due to overfishing of parent stock, an increase of natural variability due to fishing, etc. (Saville, 1980). Even though fishing probably played only a minor role in the collapse of some fisheries (Plymouth herring, Cushing, 1981), the fact remains that the collapse of many fisheries occurred during periods of intensive exploitation which clearly exceeded the level corresponding to MSY (Peruvian anchovy, Atlantic-Scandinavian herring, North Sea herring, Ivory Coast Ghana sardinella, Namibian pilchard, California sardine, etc.) (Troadec, Clark and Gulland, 1980).

Although the hypothesis of the average invariability of the environment and recruitment has proved practical in order to define and analyse the effects of intensification of fishing, the natural variability of stocks must be considered as a basic characteristic of fisheries. This variability, which is different according to the stocks and environments, must be recognized in management schemes, especially when catch methods (fleets) and processing (plants) show a sluggishness that prevents their immediate adjustment to stock fluctuations or when, because of a concern to stabilize employment, it is necessary to cut down bottlenecks and reduce off-seasons to the maximum.

In order to eliminate the negative effects of overintensive fishing on recruitment and average productivity of stocks, as well as the risks of collapse which they entail, and in order not to increase the natural interannual variability of stocks and incur sizable excess costs for the industry, and, lastly, for protection against the consequences of assessments which are overoptimistic since they are based on the analysis of fisheries performances which may have been established at the time of temporary natural increases of

stocks (Doubleday, 1976), biologists (e.g. Sissenwine, 1974) have come to the conclusion that the MSY is often an overly ambitious strategic objective for fishing. They have therefore, recommended the adjustment of exploitation rates and catch levels below MSY (Gulland and Boerema, 1973). Even though such objectives involve a certain drop of maximum MSY in the short term, these losses are modest compared to the substantial economies in research and continuous stock surveillance programmes afforded by the reduction in variability which they encourage.

The meaning of the word "sustainable", which appears in the concept of maximum sustainable yield (MSY) is important and needs to be explained. The two curves representing production and yield in Figure 1 had been established after the fishing effort, for each exploitation level, had been kept constant for enough time to allow the size and structure of the stock to become re-established after any modifications made in the fishing regime (global fishing effort and age structure of the catches). In fact, when this fishing regime is altered, the size of the stock and the volume of the catch do not reach their final balance until all the age classes subjected to the previous fishing regime have disappeared from the stock fished (a similar effect is observed, for example, in the age pyramids of human populations where the effect of wars on the age groups which fought is observed until the final disappearance of all the age groups decimated by the conflict). This inertia, which will obviously depend on the lifespan of the species, means that it is always possible by suddenly increasing the fishing effort to immediately, but only temporarily, capture more than is indicated by the sustainable production and yield curves.

2.1.2 Economic aspects

If there are statistics available on the value of catches and estimates on the various items making up production costs (capital, labour, fuel, etc.), it is easy to transform the curves in Figure 1 into economic equivalents (Figure 2). The total cost of production will be proportionate to a large extent to fishing effort while the value of landings, as a first estimate, will be proportionate to their weight. Gains in productivity can undoubtedly be achieved by an increase in the volume of fishing operations, and the average unit value of the catches is likely to drop with the quantity of the supply or the decrease in the average size of the individuals captured which always accompanies intensification of fishing. These secondary effects could slightly shift the position of the maximums and other significant points of curves (a) and (b) of Figure 1 expressed in economic equivalents. However, these distortions would still not be enough to substantially change the shape of the curves and, in particular, the conclusions that could be drawn from them concerning the position of the different objectives in relation to the axis of the fishing effort.

Figure 2 shows, in relation to total fishing effort:

- (a'), the total value of landings ($\Sigma V$);

- (b'), the gross economic return, or gross value of production per unit cost ($\Sigma V/\Sigma C$).

Starting from these estimates it is possible to deduce two other indices:

- (c'), the marginal yield ($\Delta V$), i.e. the extra gross yield (beyond the gross value of the current catches) resulting from a unit increase in the total fishing costs $\Delta C$; and

- (d'), the total net economic profit (or return or added value), expressed here as an absolute value ($\Sigma V - \Sigma C$).

An examination of these last two indices is particularly interesting. A marginal yield curve (c') passes through the value 1 - i.e. the unit growth in total costs will then be just covered by the corresponding increase in the value of the resulting total production($V = \Sigma C$ - for fishing effort decidedly less than that leading to MSY. It is also with

this effort that the total economic yield, or total net profit[1/] is at the maximum. This point is called MEY (maximum net economic yield).

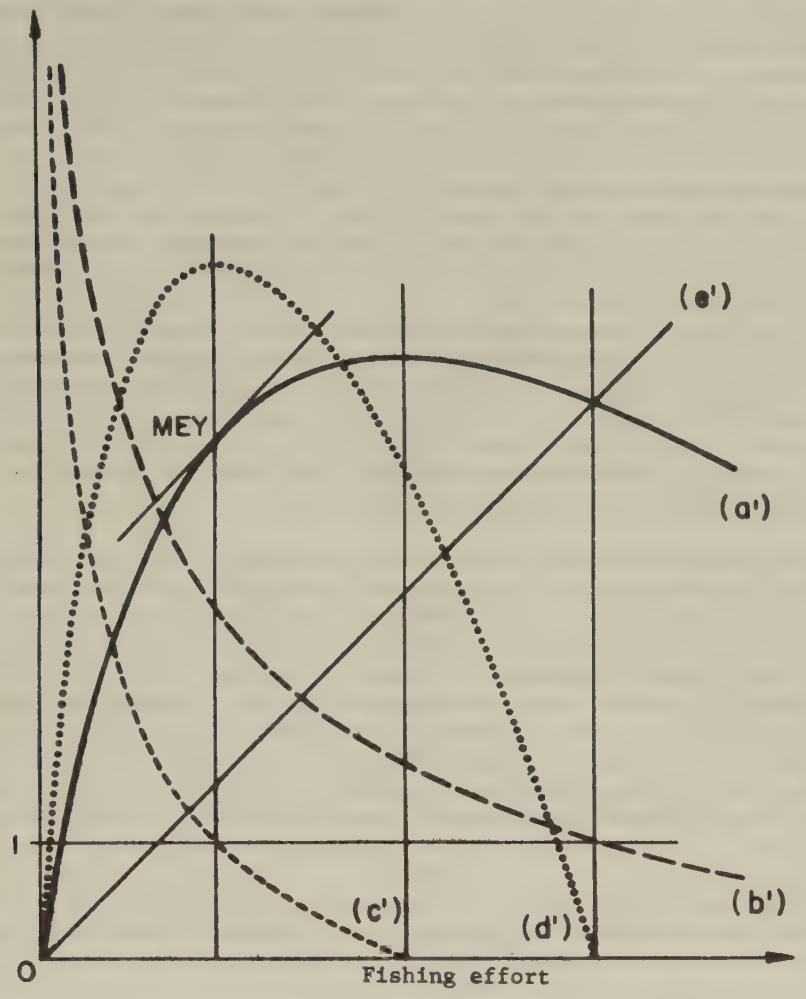


Figure 2 Economic model of a fishery consisting of a single species, a single fishing method and a single community of fishermen:

(a') = total value of catches ($\Sigma V$)

(b') = gross economic yield ($\Sigma V/\Sigma C$)

(c') = gross marginal yield ($\Delta V$)

(d') = net total economic yield ($\Sigma V - \Sigma C$)

(e') = total cost of production ($\Sigma C$)

in terms of fishing effort

N.B. The different curves are not all shown on the same scale (vertical): this does not affect the position of the points of these curves seen in relation to the axis of variation of fishing effort, the only aspect which concerns us here

---

1/ The total costs, in their meaning here, include a return for the capital and labour corresponding to their opportunity costs. The net economic yield, calculated between the total costs and the total value of the production, therefore, excludes the normal exploitation profits. It corresponds to the added value which attaches only to the intrinsic value of the resource

It is this objective which one can suppose that a single operator, for example the State, whose sole aim will be to maximize the economic yield produced by fishing the stocks in its zone of jurisdiction, will try to reach and maintain for its fishery. But there are few fisheries owned by a single operator. Because of the mobility of the individuals making up the large majority of fish stocks, it is usually impossible to allocate a particular part of the resource to each fisherman. Therefore, he is unable to take the responsibility of minimizing the fishing costs corresponding to the share of the resource belonging to him, and so extracting the economic yield attached to that resource. For him the problem is simple: each fish that he does not succeed in catching is most likely to be lost to him, whether it be captured by another fisherman or dies a natural death. On the contrary, he can hope to increase his share of the total yield by increasing his means of capture (see Section 2.3.1). In fact he will do so as long as his average returns exceed his average costs, i.e. as long as curve b' in Figure 2 will be higher than 1. Unfortunately, placed in the same position, all operators will be inclined to do the same. Moreover, potential new arrivals will join their predecessors as long as the fishery provides them with an income at least equal to that provided by other job alternatives outside the fishing sector, in other words until the whole of the economic benefit will be dissipated by mobilization of unnecessary capital and labour. Since the opportunity costs of excess labour and capital are included in the global costs of the catch - and therefore excluded from the calculation of the yield - these excess material and human resources will by definition be used better in other sectors of the nation's economy.

At present fisheries represent one of the best examples of the exploitation of natural resources where neither the number of operators - even if there are some exclusive clauses, e.g. regarding foreigners nor the volume of their respective activity are themselves limited before the zero profitability threshold is reached. Once this threshold is reached, the productivity increases of the more efficient competitors lead to the failure and withdrawal of the less efficient or less fortunate ones. The dynamics governing the exploitation of shared resources are well known; without the intervention of a central authority is doomed to economic stagnation (Gordon, 1954; Scott, 1955). In national as well as international fisheries this development may not even stop at the threshold where the average individual and global profitabilities cancel each other out. There are several reasons for this:

- there is often a delay of several years between the feasibility and investment analyses and the average operational life of ships; if one does not take into account the drop of the biomass and of yields subsequent to additional investments, the view of the average yields which the future boats will really obtain will necessarily be overoptimistic;

- each potential investor makes his decision independently, therefore without being able to take account of the decisions made at the same time by his rivals;

- investments not justified by the size of the resource are often decided following periods where the natural abundance of the stock is above normal;

- the mobility enabling fishermen to enter the fishery is often greater than that for leaving it; this asymmetry occurs frequently in artisanal fishery (Panayotou, in preparation);

- once the boat has been purchased it is easy to overlook its depreciation costs in estimating the real production costs;

- faced with the immediate social consequences of a reduction of means of fishing, which nevertheless is desirable in the long term, the fishery administrations are often inclined to subsidize the replacement of old boats as increased fuel costs, thereby perpetuating inefficient operations and inappropriate use of national financial and human resources.

The economic return, the amount of which depends apart from fishing levels, on the unit value of the catches as well as on the total cost of production can, however, be quite high. Thus, allowing for a reasonable return on the capital invested in the fleets (Griffin, Warren and Grant (1979) and Christy (1979)) have estimated that the North West African cephalopod fishery could provide the States owning the resource with a hypothetical resource

yield of an order of US$ 200 million, i.e. about US$ 1 500 per t of catch if a system to control the fishing effort were to be applied effectively. This yield is termed "hypothetical" because it can only be totally extracted if the other coastal countries controlling the other world cephalopod stocks apply the same system. In fact, the competition between the countries owning this resource is very likely to force them to leave part of the economic yield to the fishing countries. Another example is that of the Maldives where the revenues which the State derives from the country's tuna production are about twice those it pays to the fishermen (Christy, *et al.*, 1981).

In reality, the phenomenon of overfishing breaks down into three distinct aspects:

- one, of an economic character, resulting from the use of excess capital and labour which leads to a waste of the potential economic benefits;

- two others of a biological character, i.e. a drop in the production of already recruited age classes (the "growth overfishing" of Cushing, 1971) due to over-intensive fishing of the exploited phase of the stock as a whole but which is possibly concentrated on the youngest individuals; and

- the decline of average recruitment through excessive exploitation and decrease of the parent stock (the "recruitment overfishing" of Cushing, 1971).

These three phenomena appear fairly consecutively according to the intensification of the fishing rate. The fact that maximum economic production (MEY) is placed, in terms of effort, beyond maximum gross weighted production (MSY) is the result of the concavity of the total economic production curve, whereas the increase of the costs themselves is almost linear. The concavity of the total value curve is due first of all to overfishing of young individuals (growth overfishing) to which one can later add the decline of recruitment through too great reduction of the parent stock (recruitment overfishing). This sequence shows that, contrary to the anxieties currently expressed, the need to preserve stocks does not generally become apparent before the economic interest of their management. To be convinced of this one need only consider the case of low density and/or unit market value stocks whose exploitation reaches the zero profitability threshold (point of theoretical bio-economic balance toward which an uncontrolled fishery aims) before maximum production (MSY) is reached (Figure 3). Although temporarily preserved from biological over-exploitation, in economic terms such fisheries would benefit from regulation of fishing effort just as much as the ones mentioned previously.

The gap between the MEY and MSY is often even further accentuated by the relatively quicker depletion of the larger individuals and therefore, by a drop in the unit market value of catches which takes place when fishing is intensified. In the same way, the drop in abundance which occurs in the development of the fishery of the most valuable species often found in multispecies fisheries (see Section 2.2.2), is likely to accentuate this difference still further.

On the other hand there is another factor which operates conversely. Until now it had been accepted that the changes of equilibrium in the fishery occurred instantly. This is clearly not true. We have seen that the stock possessed an inertia equal to the duration of the fishing phase of the species composing it and that operators could enter the fishery more easily, i.e. more quickly, than they could leave it. This inertia has consequences for the fishery's economy insofar as both the future profits and costs must be reduced according to the respective discount rates. Dynamic models have been worked out to take account of this time effect. Unfortunately they are mathematically complex and demanding in terms of information. But they show that, depending on the value of the discount rate, the dynamic economic optimum lies between the static MEY (in which case the discount rate would be zero) and the bio-economic equilibrium point of an unregulated fishery (undetermined discount rate). In practice one will deduce from this that the economic optimum is less far (below) from the MSY than the static model suggests.

### 2.1.3 Social aspects

One can assume that at any given moment the amount of employment in the actual fishing industry will be approximately in proportion to the fishing effort[1/]. The need to limit or

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1/ Excluding possible replacements of manpower through change of the equilibriums between the production factors, e.g., through mechanization of fishing operations

even reduce fishing of a particular stock will thus have a direct effect on the number of jobs available. On the other hand, the average individual income[1/] of the fishermen will be a function of the catch per unit effort (curves b and b' on Figures 1 and 2), that is to say, their average individual incomes will be all the higher as the fishing rate is lower.

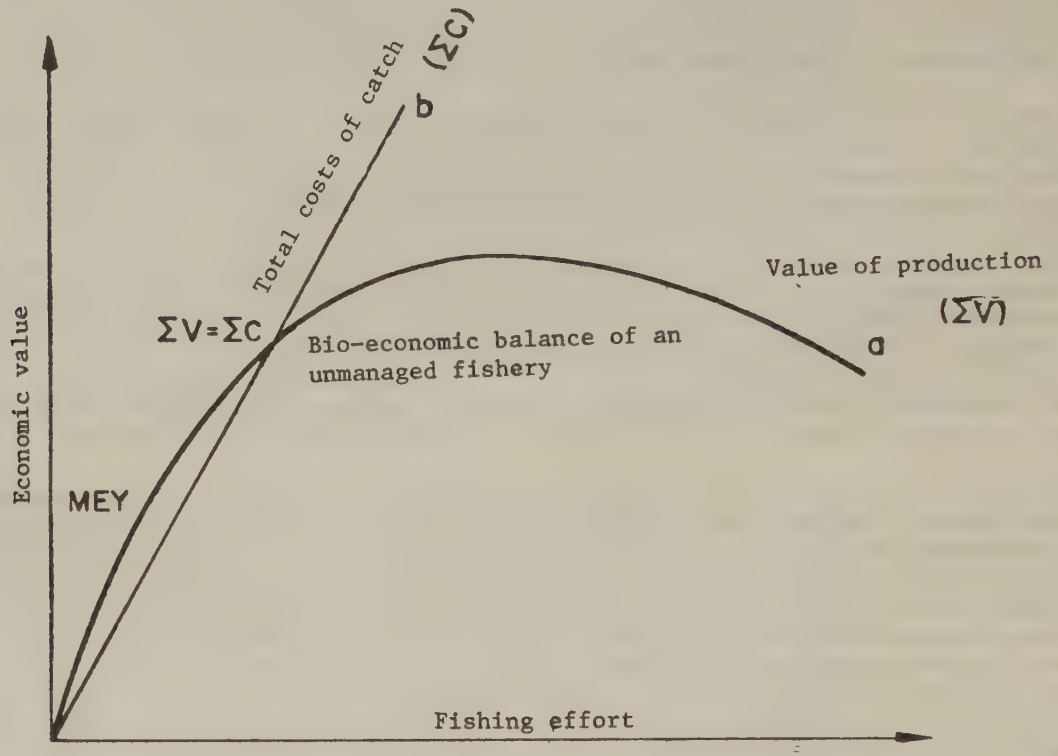


**Figure 3** Evolution of the total value (ΣV) of catches (a) and total costs (ΣC) of production (b) in terms of fishing effort in a simple fishery where the value of catches is low compared to their fishing costs; the economic profitability disappears before the stock is fully exploited; nevertheless a regulation of fishing effort is necessary in order to obtain an economic return from the fishery

That is why maximization of employment and improvement of average individual incomes are in direct conflict. In all fisheries, the level of fishing is influenced by the minimum acceptable individual income in the light of the alternative employment opportunities which exist outside the fishery sector. In the developing countries subject to a high unemployment rate, fishing is one of the last remaining job opportunities for a labour force lacking training and capital (land). In areas where resources accessible to artisanal fishing are limited they are often reduced by the development of commercial fishery, which has been the beneficiary of fishery promotion plans in the past, or where there are few prospects of employment outside the fishing sector and where there is a potential mass of people already to enter fishery (Panayotou, in preparation), overpopulation seems to be the major constraint and the opportunity cost of labour (fishermen) the dominant factor in determining the exploitation level: the best, and possibly the only, way of improving the fishermen's individual income appears to lie in the creation of employment opportunities outside the fishing sector (Smith, 1979) in an attempt to reverse the flow of manpower between fishery and the other national economic sectors.

Another example of the conflict between employment and individual income is provided by the situation of some developing countries like Mauritania for example, which have abundant fishery resources but whose national fisheries are still small. To encourage

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1/ Sizeable differences can be seen between the individual yields of different fishermen; but these differences in efficiency and the returns attaching to them do not directly concern the authority in charge of management who must deal mainly with average situations for the profession as a whole

their nationals to take part in exploiting the stocks which they now fish with foreign partners, such countries could consider it preferable to block foreign fishery (and the royalties they derive from it) at a level where the stock density can remain sufficiently high to compensate for the lower efficiency of their fishermen (see Section 2.3.1), at least at the start. Furthermore, countries such as Canada and Norway, which have resources exceeding the needs of their domestic consumption, might wish to block the fishing of certain stocks at sufficiently high levels to guarantee adequate incomes to their fishermen in order to maintain a certain distribution of their populations on their national territory.

In countries where the opportunity costs of labour are low, particularly because of the effect of unemployment, total exploitation costs will be comparatively small. Consequently there will be a shift of the MEY toward the MSY: in economic terms the employment of relatively more abundant labour and the exercise of a relatively higher fishing effort will therefore be justified. But the socio-economic optimum will not be able to reach the MSY for that would mean accepting that the total costs of production, including the opportunity costs of labour, might be nil.

The frequently-held opinion that the total volume of employment increases with the fishing rate is no longer valid if, at the same time, one considers the effects on employment in related industries (processing, distribution and marketing) as well as the repercussions on the gross national product. Although activity in shipbuilding is still based largely on fishing effort, this is no longer true in the industry's secondary activities. The volume of the latter's activities will depend mainly on the tonnage of catch landed. Employment in this sector should therefore, be at its maximum around the MSY. Now, the number of jobs in the secondary and tertiary downstream sectors could be several times greater than that of the primary sector. There are very few estimates of the multiplier effect: coefficient of 2 to 3 are mentioned for the artisanal fisheries sector; possibly they can reach 7 or 8 in some industries fisheries. In fact, the higher the net economic and social benefits in processing and marketing compared to those obtained, at equal weight, in fishing, the more worthwhile it will be to obtain a catch higher than the MEY and close to the MSY. Moreover, the effects of rationalization of fishery on economic growth must be considered. We have seen (Section 2.1.2) that the fishing effort is now controlled at a level close to MEY and could produce substantial economic returns: they could be used:

- either by the authority in charge of fisheries management, to create new jobs through promotion of new fisheries to operate on resources that are still underexploited, or new activities (aquaculture, for example);

- or by the fishermen themselves to create complementary or substitute activities (e.g. tourism) and to improve their working gear which would lead to extra work in shipyards and in the fishing gear industries (Newton, 1978) and their standard of living (e.g. housing).

The fishing rate leading to maximum employment in the fishing sector as a whole will therefore depend only partly on the labour force engaged in fishing activities. It will also depend on factors such as labour opportunity cost, the slope of the production curve, the share of labour costs in total production costs, the multiplier effect in complementary activities and the net economic income produced by the fishery. In many fisheries maximum employment may not be as far from the MSY as is commonly accepted and can even be below it. A fishing policy having social benefits as its major objective would therefore, have to be based on an appropriate analysis of the relevant factors involved.

## 2.2 More Complex Situations

### 2.2.1 Sequential fisheries

The homogeneous and clearly defined fisheries examined in the previous section are hardly ever encountered in real life. If within the same fishery there are separate groups of fishermen distinguished by the fishing methods they employ or by their social and professional backgrounds, they are likely to concentrate their activities on fish of different ages. The terms of their competition will therefore be altered in the sense that the respective capacity of different groups of fishermen to mutually harm each other will no

longer be equally distributed. The Penaeid shrimp fishery (*Penaeus duorarum*) in the Gulf of Guinea provides a good example of the complexity of the problems which can arise when different gear or specialized fishing methods for the capture of individuals of different ages are used by separate social groups in different fishing areas or seasons.

Spawning takes place at sea, and the larva quickly reach nurseries located in lagoons and river mouths. There they spend several months before migrating to sea, where they colonize relatively defined bottoms. Sexual maturity takes place after this migration. Shrimp die naturally after about a year and a half. During this cycle they are first fished at the time of their migration from the lagoon to the sea. This fishing is mainly done with fixed gear which the artisanal fishermen place across river mouths and passages. Out at sea the shrimp are fished by specialized trawlers and, incidentally, by trawlers seeking fish.

Stock assessments show that if there is an attempt to maximize production, artisanal fishery harvests individuals which are too young. By delaying their capture one can expect to increase the overall lagoon + sea yield considerably (Garcia, 1976). The advantage is even more obvious if it is expressed in monetary terms, since the unit market value of shrimp increases with their size. Were it not for the fact that tropical penaeid shrimp have generally shown good resistance to exploitation, there might also be cause to fear that an intensification of lagoon fishing could affect the survival of the stock, since lagoon fishing involves individuals which have not had an opportunity to spawn; this danger could be all the more serious inasmuch as those individuals are much more vulnerable because of their concentration during migration.

All these observations argue in favour of sea fishery and a reduction in lagoon fishery. However, research over a wider field would probably show that lagoon fishery is not necessarily as irrational as this consideration of its biological aspects alone suggests. The following table summarizes the specific characteristics which distinguish the two fisheries.

In fact, it has been demonstrated in the Ivory Coast fishery that every net increase of one dollar in lagoon fishing led to a drop of 4 to 6 dollars of net yields in trawl fishery; on the other hand, the first used nearly ten times more fishermen than the second. Lastly, the development of lagoon fishery, by directly reducing its recruitment, may have caused the economic collapse of trawl fishery (Griffin *et al.*, in preparation).

| Factors | Lagoon fishery | Sea fishery |
|---|---|---|
| Total production | low | high |
| Stock availability | concentrated phase | dispersed phase |
| Fishing grounds | littoral | open sea |
| Cost of fishing gear | low (pirogues) | high (trawlers) |
| In foreign currency | none | often considerable |
| Fuel consumption | low (passive fishing) | high (active fishing) |
| Processing costs | lower (on land) | higher (partly at sea) |
| Employment | high | moderate |
| Foreign expertise required | none | considerable at first |

In order to make an objective judgement of the relative and absolute importance to be attached to both types of fishing, we would need to have assessments enabling us to compare the respective performances of the two sectors on the economic and social levels, particularly in terms of:

- economic profitability and net profits;

- distribution of the net profits between the two sectors and, indirectly, between rural and urban areas;

- investments (both in absolute values and in foreign exchange) required per t of yield and per new job created (the individual cost of job creation is a major criterion in the choice of development strategies in the developing countries where the absence of capital and strong currencies often constitutes a major obstacle to development); and

- the volume of additional jobs, in absolute value and in rural areas (to evaluate the possible contribution of artisanal fishery in the struggle against the rural exodus, for example).

This simple example shows that identification of suitable management in development objectives is not so easy when one considers fisheries having a heterogeneous structure, and that the field of research necessary to the formulation of rational fishing strategies goes far beyond the framework of a simple assessment of the effects of intensification of fishery on production and stocks. Fishing is an activity whose objective is to obtain a maximum of net economic and social benefits. The conservation of the resource and its maintenance at a level which can produce the desired profits is a condition of that objective. Unfortunately until now there have been assessments aimed at analysing the economic and social terms of management. That is why there is an urgent need for carefully chosen simulation studies covering the whole range of biological, economic and social factors.

2.2.2 Multispecies fisheries

There are few fisheries dealing mainly with only one species. The importance acquired by multispecies fisheries (FAO, 1976) in the past few years has two main causes:

- even in northern latitudes where the number of species is smaller, intensification of fishing has been accompanied by diversification of catches and landings (decrease of rejects); many species which were secondary or rejected in the past have become target species;

- greater attention is now being paid to assessment of tropical fisheries where the exploitation of demersal stocks normally covers several dozen species.

Moreover, the small administrative capacities of many countries force them to undertake the management of their fisheries through large, necessarily heterogeneous groups.

Trawl fishing, in particular, simultaneously captures species with different catchability, demographic parameters and commercial value. In this case, what will be their combined maximum production? What fishing rate will provide the maximum net economic yield when the fact that the species are fished simultaneously makes it impossible, in practice, to apply to each stock any specific fraction of the overall effort?

Globally the response of multispecies stocks to an intensification of fishery is similar to that already described for single species fisheries (Section 2.1.1): a steady decrease of total yields corresponds to a diminishing increase of total catches until a maximum or threshold is reached. In fact, one can approximately assess the multispecies stocks and the situation, in terms of optimum fishing effort, of different management objectives by applying a global model similar to that described in Section 2.1.1 (Pope, in press).

However, there is a fundamental difference: the species composition of catches is bound to change, either as a result of differences in the selectivity with which the different existing species are captured or due to the effects of an intensification of fishing on the specie composition of the stock. These changes are the result of interactions of a technological (fishing method) and biological order.

So far as the first of these is concerned, one can try, applying various available methods, (mesh size and gear selectivity, use of new gear like the vertical wide opening trawl, regulation of the distribution of fishing operations in space and time) to find ways to improve the selectivity with which the fleet "filters" the multispecies resource accessible to it in a given space and time. As in single species fisheries where one tries to improve the value of yields by exerting action on size composition, here one will try, by

the selectivity of the fishing, to lift the yield curve more (in value). But the possibilities are few because species are captured simultaneously, which prevents distributing nominal fishing effort at will among the different species, and because of the freedom enjoyed by fishermen to change the time space distribution of their fishing operations.

Concerning exploitation of species or stocks accessible to the same fleet but in part caught separately during separate fishing operations (e.g. different shrimp fishing grounds, different tuna species in surface fishing), the ships will tend to spread the economic returns obtained equally over the different components of the multispecies stock. This practice, which is generally acceptable in economic terms, in principle reduces the problem of the rationalization of the exploitation of multispecies stocks. There is a risk, however, that it may lead to the extinction of the most valued species when the fishery remains economically viable with species of less immediate economic interest, and that the former are encountered during operations aimed at the latter. For example, this scenario has progressively endangered the main large Antarctic whale species (Gulland, 1974).

The changes in the species composition of stock under the effect of intensified fishing result from differences in their catchability and their demographic parameters especially of natural mortality as well as some biological interactions between the different species (Pauly, 1979). When the nominal total effort increases one can see that the yield maximums of the principal species composing the stock are reached and exceeded sequentially: this inevitably leads to biological overfishing of certain species while others continue to be underexploited. A complex, and irregular, network of relations of predation and competition links the various species to one another. Thus the abundance of a species, over and above the direct effects of its own exploitation, will also depend on the natural fluctuations and on the fishery exercised on other species to which it is linked trophically or otherwise. These relations are complex, since they change with the size (and age) of predators; thus a predator's prey (small pelagic species, for example) could quite probably eat that same predator's eggs and larvae.

The relations are also changeable according to the availability of targets, since opportunism appears to be a major characteristic of the trophic relations in fish (Le Guen and Chevalier, 1982). Consequently, although these questions are now receiving increasing attention, an understanding of the reactions of multispecies stocks (both in their abundance as a whole and in their species composition) to intensification of fishing is still far from giving rise to even approximative management rules. For example, Régier (1973) suggested that the intensification of fishing and the degradation of the environment (pollution) in the North American Great Lakes were accompanied by a progressive scarcity of the species occupying the upper trophic levels which were generally the most valuable. On the other hand, Pauly (1979) maintains that in the Gulf of Thailand demersal fishery, on the whole the prey species caught have declined more rapidly than their predators. Furthermore in many regions (North West African coasts, Thailand), large cephalopod stocks of very high commercial value appeared after the intensification of trawl fishery.

Until we have a better understanding of the evolution of the exploited ecosystems their management must remain empirical. Briefly, the strategy could be the following:

(a) to follow the evolution, in weight and composition (age and species), of catches in terms of the intensification of exploitation and changes in the selectivity of the fishery;

(b) to transpose this evolution in economic and social terms (value of catches, costs of production factors);

(c) to attempt experimentally to raise the production curve in value by operating on the selectivity of the fishery taken as a whole (mesh size, gear used, time-space distribution of fishing operations); and

(d) at the same time, to determine the fishing rate corresponding to the exploitation objective chosen.

Nevertheless, these complexities do not in any way change the fundamental characteristics of the problem of fisheries management as described in the case of a single species fishery (Section 2.1): the resources available in each national exclusive economic zone are

limited. For any given exploitation method (global selectivity of all national fisheries, costs and earnings structure) an overall production limit will be reached; during this development the marginal cost will be increasing steadily until it reaches the value of the gross marginal profit.

## 2.3 Application of These Concepts and Examples of Conflicts Between Various Possible Development and Management Objectives

### 2.3.1 Increase of fishing effort

In section 2.1.1 the immediate and long term consequences of changes in the exploitation rate were described. Gulland (1968) has studied the relative error involved in planning which fails to take into account the decline in yields following a contemplated increase of fishing effort. Figure 4 outlines these effects for a $\Delta f$ growth of fishing effort f already being exerted.

Before this increase is achieved it is assumed that the stock had been in equilibrium; its density, represented by the angle $\theta_A$, was then proportional to the catch per unit of effort $AE_A/OE_A$ corresponding to the fishing rate A. Once the increase of effort ( f) has been made, the stock gradually becomes stabilized at a new equilibrium corresponding to fishing rate B; its density will then be represented by the angle $\theta_B$, and production will be equal to $BE_B$.

Because of the slope of the production curve, the actual marginal gain BC obtained in the long term will always be less than the growth DC expected beforehand. The BC/DC ratio is called the marginal efficiency of the additional effort $\Delta f$. It is cancelled out at MSY and then becomes negative.

The marginal efficiency is not the same if the increase in catch methods affects only a part or sector of the fishery. In that case one can demonstrate that the difference between sectorial marginal efficiency and global marginal efficiency is greater - always in favour of the former as the sector is small in relation to the fishery as a whole. Should it be small enough, the marginal efficiency could remain positive even if that for the fishery as a whole is negative. In simple terms this means that a fisherman or a crew can always expect to increase their catches, even if the stock is already being fished beyond maximum sustainable yield. This is another manifestation of the conflict between immediate individual interest and long-term collective interest which leads to economic stagnation of fisheries.

An illustration of this concept is provided by the study of the effects of sectorial increases of fishing effort on the schemes for allocation of resources. This will be the case, for example, of canoe mechanization programmes or of any other plan for increasing catch capacity concerning only one segment of an artisanal fleet, or the assignment, for example to foreign ships, of licenses for fishing of stocks already exploited by national operators or, again, of development of an industrial fishery on stocks already exploited by artisanal fishery. If the segment exercising the effort $\Delta f$ is responsible for a production increase equal to BC, its total production BG will be achieved in part (which will vary according to the respective positions of $E_A$ and $E_B$) at the expense of fleet $E_A$ which is already operating (Figure 4). In other words, the growth in means of capture$^A$(f) in one section causes a drop in yields ($\theta_B$ $\theta_A$) and production (AF) in the fleet already operating.

### 2.3.2 The consequences of innovations, subsidies and changes in fishing costs and the value of yields

It is interesting to analyse the probable effects of the different factors liable to change the equilibrium of a fishery in which:

- the accessible resource is limited;
- the number of fishermen and the effort exerted by them are not controlled; and
- there are few possibilities of transferring labour outside the fishery system.

This is the situation, in particular, of many artisanal fisheries in developing countries (Panayotou, 1980). In these conditions, the fishery tends to stabilize at a point where total costs equal total earnings, the latter being established at the minimum

wage level acceptable to the fishermen, bearing in mind the possibilities of outside employment and of the mobility of the fishermen and the unemployed who are likely to join them. The acceptable minimum income, excluding operating costs, will be equal, in principle, to the opportunity costs of capital and labour. But if mobility is low, the net income can fall below the opportunity cost (Panayotou, in preparation).

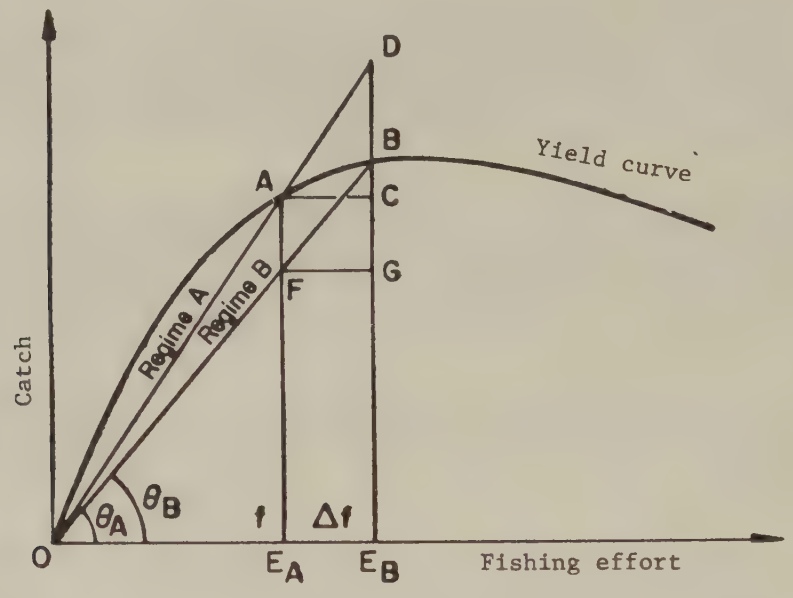


Figure 4 Effects of growth of fishing effort ($\Delta f$) on a fleet already in operation (f) and on a fishery as a whole

$AE_A$ - total catch under fishing regime A

$BE_B$ - total catch under fishing regime B

BC - increase of actual catch following increased effort $\Delta f$

AF - loss of catch for the fleet (f) already in operation

BG - catch obtained by additional catch capacity $\Delta f$; it should be noted that BG = BC + CG, in other words the additional catch made through additional means of capture, is obtained partly (CG) at the expense of catches already made by the pre-existing fleet (CG = AF)

Figure 5 shows the effects of changes in the cost of catch. It may go up, particularly under the influence of a rise in the cost of fuel, or go down, thanks to increased efficiency resulting from the introduction of technological innovations or the granting of subsidies. Likewise, Figure 6 shows the effects on the fishery of changes in the value of the catch due to other causes. In both cases, once the fishery has attained an equilibrium, the major effect is on the fishing rate and on the amount of employment and the degree of capitalization of the fishery. Conversely, one may say that in a fishery to which access remains free, any government intervention (subsidies for purchase of diesel fuel, technical assistance to artisanal fishery, etc.) the main consequence in the long term will be to change the amount of employment and the degree of overcapitalization, but not the individual income of the fishermen inasmuch as the latter is mainly determined by the employment opportunities outside the fishery sector. Subsidies for purchase of diesel fuel, in particular, will not bring about any lasting effect on the economic state of the fishery (FAO, 1981b). If the authorities responsible for management intend to maintain the level of employment and individual remuneration by this means alone, we must expect all future increases of the price of fuel to be covered in the subsidies. In the long term such a policy is liable to cause a biological overexploitation of the stock with a drop in total production and, therefore, in employment.

The medium term effects of certain technicological improvement programmes aimed at increasing the fishing strength of the existing catch capacities can be studied on the same model. In Figure 7 the effects of a programme to mechanize canoes have been compared for two different levels of development of the fishery: one which is still moderate (1) and one which is high (2) but does not as yet correspond to full utilization of the resource. It is assumed, arbitrarily but optimistically, that mechanization will lead to an average rise of 10 percent in the total costs of the catch and an increase of 50 percent in fishing power. In both cases the point of departure is a balanced regime where the gross costs and total earnings are equal (bio-economic balance). We find that while in the case of fisheries which are still little developed, the mechanization programme is likely to result in a net gain in the medium term, and thus to promote the development of the resource - such action can lead to a net lose in the long term in a case where the resources are fished more heavily, even if it is applied to a fishery not yet fully exploiting the resource at its disposal. Yet the littoral zones where artisanal fishery operations are concentrated are generally very intensively exploited already. There is therefore, a real danger of impoverishing the fishermen or reducing employment when such programmes are adopted without having given due attention to the exploitation rate of the available resource.

If the mechanization of canoes aims at increasing the volume of the resource accessible to the fleet by extending the latter's range of action, it is possible to push down the point to the level at which the net gains are cancelled out. Unfortunately, even further out to sea resources not yet fully exploited do not always exist (mainly as a result of competition with commercial fleets), and mechanization plans combined with measures which can ensure that mechanized canoes will really fish further offshore and will not add to the overexploitation of an already crowded coastal strip are exceptional. Such mechanization programmes, far from postponing the regulation of effort directly, pose the problem of control of its distribution in time and space which, in reality, implies that the effort can already be controlled.

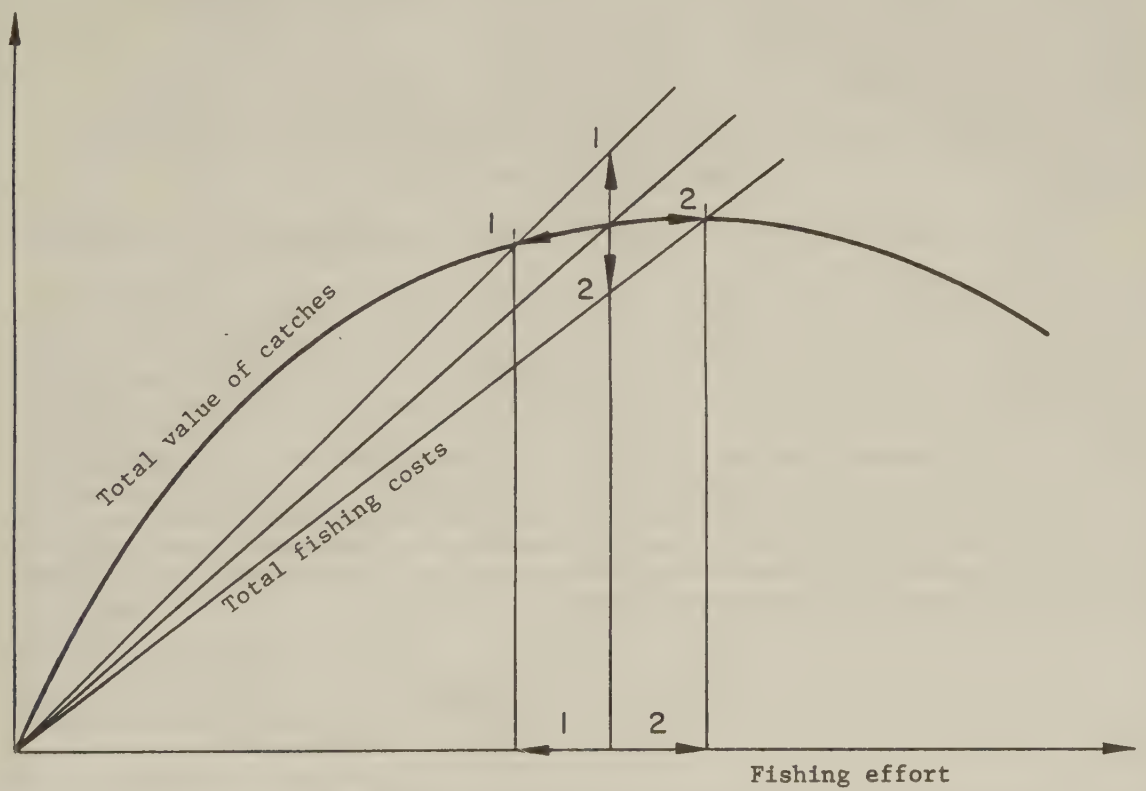


Figure 5 Effects of changes in the total cost of production in a simple uncontrolled fishery:

1. An increase in production costs (e.g. fuel or labour) results in a drop in the fishing rate and, consequently, in total employment;
2. A drop in the costs of catch (e.g. increased efficiency through the adoption of technological innovations, subsidies) results in an increase in the fishing effort and, consequently, in total employment, and intensifies overcapitalization. In both cases individual income is unchanged

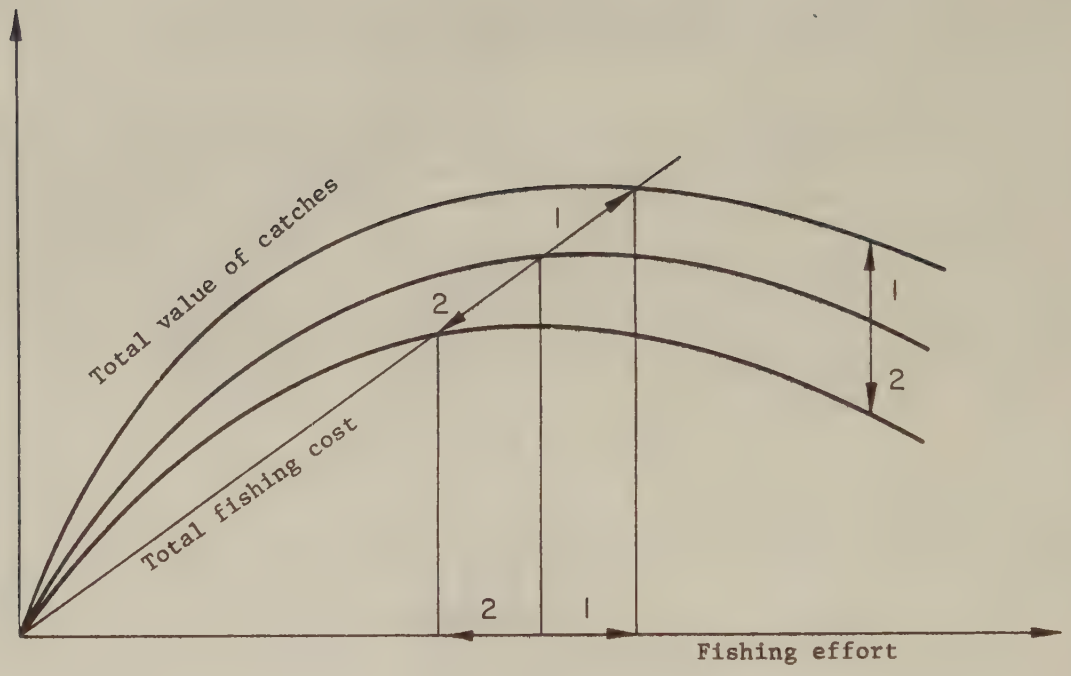


Figure 6 Effects of changes in the total value of catches in a simple uncontrolled fishery:

1. The increase in value (e.g. by an increase in the price of fish, the adoption of controls on mesh size, changes of the pattern of rejects and marketing of fish sizes previously rejected, expansion of the range of action of fleet and a growth of the accessible stock, etc.) brings about a rise in the fishing rate, and consequently in employment, and increases overcapitalization;

2. A drop in the total value of the catches (e.g. through a fall in the selling price, natural decline of a stock, reduction of accessible stock due to greater participation of a competing fleet, etc.) brings about a drop in the fishing rate and, as a result, in employment.

In both cases, net individual income is unchanged

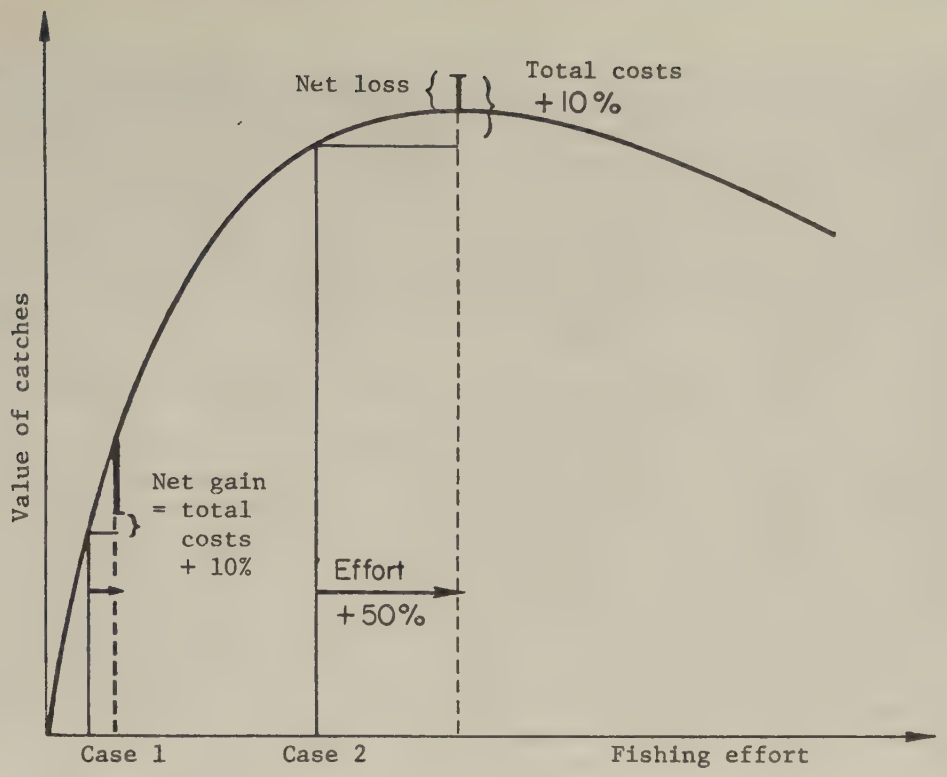


Figure 7 Example of the medium-term effects of mechanization for two different levels of fishing. Hypothesis: in both cases mechanization is supposed to bring about an increase of 10 percent in the total cost of capture and an increase of 50 percent in the fishing effort. If the effort is low (case 1) mechanization leads to a net gain in the medium term and can thereby contribute to the development of the fishery in the long term. If the effort is already high without, however, yet having reached the level of full exploitation (case 2), mechanization can cause a net loss in the medium term and therefore impoverishment of the fishermen or the departure of the least competitive among them.

## 2.4 Clarification of Objectives

This brief review of the dynamics of fisheries shows that every country has the possibility of using the fishery resources available to it in different ways: to increase production - in value (economic returns) or in weight (protein supply) - exports (foreign exchange), employment either in the fishery as a whole or primarily in certain socio-professional sectors (to slow down the rural exodus), etc. The balance which will be ultimately accepted will depend on the specific needs of each country as well as its advantages and handicaps. Thus the profound divergences which one can see in the philosophy of the different geo-political blocks, such as the countries of North America, those of Eastern or Western Europe, Japan, and the different groups of developing countries, etc., concerning the development and management of fisheries are largely explained by the weight represented in their respective economies by key constraints or prospects such as the need to ensure the protein supply of their populations, the chronic difficulties of ensuring full employment or the possibility of drawing substantial economic yields from abundant resources (Royce, 1965).

The choice and establishment of development and management targets should not take into account only the gross value of production or incomes. In fact, only the strategies which at the same time consider the corresponding costs and compare them to the potential profits deserve consideration since, whatever the unit in which they are expressed, they are the only ones that can maximize the net benefits.

This review has also shown that most of the targets which can be contemplated (economic, social, food) are reached through different exploitation levels. This characteristic of fisheries makes these different targets partly incompatible. Nevertheless this disparity should not be exaggerated. In a great many contexts the long-term objectives of management ultimately prove to be fairly close and on the average often below maximum

weighted production compared to the point of bio-economic balance at which fisheries whose exploitation level and selectivity are uncontrolled tend to stabilize. Therefore, the identification of the objectives that can be considered and a comparision of the conditions of their execution will be followed by their hierarchization and integration in a long-term fishing policy. The formulation of such a policy will be facilitated by analysing the long-term perspectives of the contribution that the fisheries sector can make to the national economy. The final choice of an overall guiding plan will require decisions of an essentially political character inasmuch as any intervention, as well as any lack of it, will have effects on the distribution of wealth among the different socio-professional groups. But the assessment of the various biological, economic and social aspects of fisheries should contribute to a better appreciation of the long-term advantages of management and the implications of the various options open and, finally, encourage the adoption of decisions.

The selection of the various objectives assigned to each fishery will at the same time give rise to objective criteria for evaluation of the benefits and sacrifices which justify development and management. In particular, these criteria will make it possible to judge the importance of decisions concerning the distribution or redistribution of catches and the wealth they can produce and the political difficulties to be overcome, the costs of research, administration, control and monitoring, etc., to be undertaken, which justify the fishery. Such costs must all be considered together in the quantitative evaluation of each fishery and the establishment of the optimum fishing rate. If they are very high one could be led to renounce managing those fisheries, at least temporarily. Lastly, these criteria will make it possible to evaluate the performances of development and management plans later on.

## 2.5 Development and Management

At first sight it is surprising to see how few fishery development plans are based on an overall evaluation of the national fisheries and their long-term prospects. Many of them are set in a sectorial approach whose limits we have seen in section 2.1 and 2.3.1, particularly with regard to the prevention of overfishing. Perhaps there are even fewer feasibility studies which consider the possibility of changing fishing effort (particularly to reduce it) to reach the objectives chosen. Yet this variable is the essential chain of transmission in the improvement of fisheries. Such practices of the past can doubtless be explained by the fishery regime existing before the extension of national jurisdictions, which placed national administrations, and indirectly also, the planning agencies they employed, in a position similar to that of an isolated fisherman in an open fishery. Although world fishery production was globally limited, this limit was not individualized at the country level since each country could always increase its activities to the detriment of those conducted by the others. In the case of national fisheries operating on stocks also exploited by long-range fleets or by neighbouring countries this observation is obvious. For each country, the only strategy that could be considered was to increase its catch capacities in the hope of increasing its participation more rapidly and more efficiently than that of its rivals. Even in the case of stocks exploited solely by national operators, it was difficult for national administrations to impose limits to national expansion in view of the ever present prospect of increasing the national fisheries through expansion of their activities beyond the territorial waters. That is why even in purely national fisheries an indiscriminate expansion strategy was able to prevail; because of the competition, any other would have led to a decline of the national share. The new law of the sea makes it possible to escape from these conditions and warrants new practices. The theory of fishery shows that national natural, financial and human resources can be utilized appropriately now that a central authority may intervene to maintain the rate of exploitation in the national fisheries at the level corresponding to the selected development objective.

The theoretical analysis of fisheries has shown that development occurred by itself as soon and as long as a fishery produced net profits. Figure 3 shows that development consists basically of widening the distance between the value curve and the curve for total production costs. The choice of strategies to achieve this must be based on an overall analysis of each fishery in order to identify and give a sequence to the fundamental constraints (amount of resources available and the potential that can be caught, value of the products, cost price of catches and structure of capital costs, labour, energy) which limit the space it is likely to occupy.

Thus, in the case where resources allow for a substantial increase in production, a comparison will be made between the prospects offered by reducing the production costs and increasing the value of the catch. In general terms, assistance to financing of fleets or improving fishing methods will be reserved for situations where the cost price of the catch or of processing is too high and constitutes the major constraint - compared to the prospects for increasing the value of production and where lowering them depends on introducing new techniques and equipment which it is difficult for the fishermen to obtain for themselves. On the other hand, this kind of intervention is scarcely justified when it is aimed simply at quantitively increasing the volume of current operations. In fact, if the fishery produces net profits the latter is most likely to occur without outside intervention.

So far development programmes have often taken too little account of the consequences of the limited nature of resources and free accessibility to their exploitation. This is especially the case of artisanal fisheries in Third World countries (Smith, 1979). Moreover in these countries the development model of industrial fishery in the advanced countries has often been directly transposed, thereby applying exploitation systems (costly in capital, foreign exchange, energy and technology) unsuited to local conditions (abundant labour, limited infrastructures and human capacities). In this effort at promotion the emphasis has been placed mostly on increasing the means of capture, whereas the constraints often come afterward, in the placement of the products or in the fisheries environment. The choice of unsuitable exploitation methods and an incorrect identification of priorities in development programmes could only lower the profitability of the operations and, therefore, reduce the competitivity of countries already handicapped by their lower level of technological and economic development in their competition for participation in the exploitation of international stocks (Troadec, in preparation).

Bearing in mind the specific dynamic of fisheries, state intervention plans should deal with the factors over which the profession itself has less or no control, i.e.:

- determination of the fishing potential accessible to each fishery;

- decisions concerning allocation of resources (see Chapter 4), especially those aimed at giving operators guarantees on the future of their participation in the fishery and, in particular, the assurances that the competition within and outside the fishery for access to the resources they exploit will be controlled, and that they will thus be guaranteed in acceptable income[1/];

- the opening up of markets, particularly to the fishery, to sell off the production at the most remunerative prices, etc.

In both development and management it will be necessary to optimize the structure of production costs so as to maximize net profits. In this respect both functions are identical, as are the research studies and analyses enabling us to identify them. On the other hand, development will be attained by increasing one or several production inputs (capital, labour, energy), while management will mean simultaneously maintaining fishing effort at the level corresponding to the selected objective. It is from this point of view, and from it alone, that the two functions can be regarded as distinct and sequential. Even in a developing fishery, expansion could be promoted by control of the fishing effort and of access to the resource by operators so as to maintain its profitability and stimulate investments. Likewise, in a fishery where the resource is already fully exploited, it will still be necessary to try to increase the economic return by improving the value of the raw material while reducing the production costs. Development and management should thus be seen as two complementary functions operating (to different degrees, of course) at all the stages of a fishery's expansion.

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1/ This last aspect is particularly important in artisanal fisheries: if the mobility of the fishermen is slight, their incomes will be lower than their opportunity costs. This manpower will therefore no longer be used rationally; by definition, there are more remunerative possibilities elsewhere

## 3. CONTROL OF FISHING

In order to control fishery and attain the selected fishing objectives, man can intervene directly only in two ways:

(a) by controlling the total effort;

(b) by changing the distribution of that effort and the different age classes and species making up the stock.

### 3.1 Selectivity of the Fishery

#### 3.1.1 Age and size of catches

We know that by changing the average age of the catch (and especially the age after which a specie begins to be fished) it is possible to improve the yield of a stock for a given level of effort to some extent and, consequently, to proportionately increase its yield in weight, yield and economic profitability of the fishery (Figure 8). This is the justification for regulations and gear selectivity, i.e., mesh size of trawls or of gillnets, escape hatch of pots, etc. But this method does not constitute the only form of intervention. One could prohibit fishing in areas and seasons in which there is an abundance of too small individuals. Such regulations could be combined with measures designed to prohibit the landing and marketing of sizes below a certain limit.

Although the extent of the improvements which can be achieved in this way is limited (in general hardly more than 10 to 20 percent, especially in multispecies fisheries where it is not possible to fish each specie with the optimum mesh size), they are still not negligible. In fact, they are achieved without any increase in the fishing cost except that caused by application of the regulations. Nevertheless, several fishing methods are not very selective (e.g. seine net fishing). This seriously reduces the possibilities of applying that regulation method.

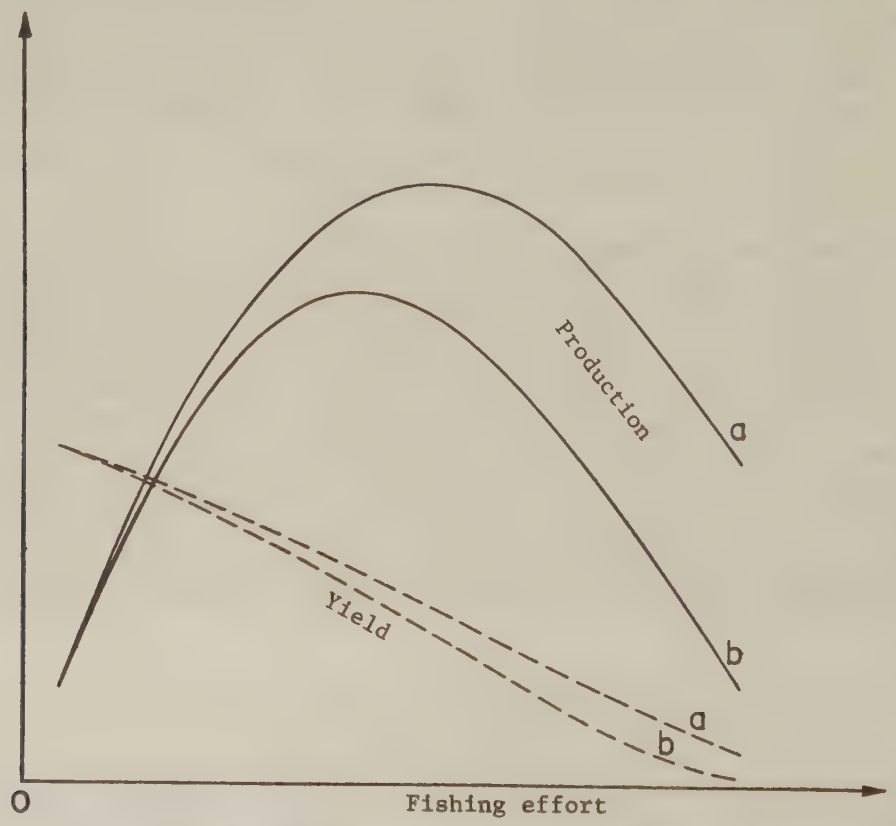


Figure 8 Effect of changing the age of first catch (or mesh size) on production (upper curves) and yield (lower curves):

(a) first catch, small size
(b) first catch, large size

3.1.2 Species

The multispecies fisheries add to this problem that of optimization of distribution of effort on the various species composing the stock. In fact, the problem of the selectivity of a fishery is wider in scope than the common definition, i.e. how, in a space accessible to one or several fleets possibly applying different gear, exerting different efforts on several species and age classes of the stock, can one improve the distribution of the operations of the available fishing capacity so as to maximize the yield of the resource? Here, besides the methods already mentioned in the preceding section, we may add the regulation of development of new gear (e.g. vertical wide opening trawl) so as to increase the fishing of species which are relatively underexploited (Pope, 1980). The simultaneous reduction of the global costs of fishing is also part of this problem insofar as it determines the development of stocks not yet exploited for economic purposes.

However, applied by itself, selectivity cannot counteract the tendency of fishermen to acquire additional fishing inputs nor, therefore, prevent the dissipation of economic benefits including those resulting from adoption of a regulation on mesh size (section 2.3.2; Figure 6). Consequently, in fisheries management the regulation of selectivity can only be a useful complementary measure, but in no case can it be a substitute for control of the fishing rate.

3.2 Regulations of the Fishing Rate

Control of the fishing rate poses considerable problems of a political, theoretical and operational order. At the technical level the basic difficulty lies in the fact that control of the fishing rate actually corresponds to that overfishing mortality[1/]. Now, this aspect cannot be measured either directly or indirectly, in other words in actual time. One can follow its evolution by observing other factors which are more or less directly linked to it, such as total catches, the biomass, fishing effort, or catch capacities. Conversely, one can try to control fishing mortality by establishing catch quotas or blocking fishing effort or, better still, catch capacities.

Unfortunately there is no strict relationship between fishing mortality and each of these controllable factors when taken individually. In each relationship several other aspects intervene, some of them depending on the fishermen, others on nature. If they are not fully mastered, these factors, which are complementary to that being controlled, will cause enough distortions in the management schemes to bring about their partial failure. The risk is all the more serious in that the conversions between the controllable factors and fishing mortality can only be established after a variable, but considerable, period of observation and analysis. It is therefore, important to anticipate the possible distortions and their magnitude, and all the more so inasmuch as the times between the follow-up of the fisheries and application of suitable corrections to the management schemes will be considerable.

The purpose of the next section is to review the main causes of the specific distortions characterizing the main relations used to control fishing mortality. In this way we shall try to identify their respective advantages and shortcomings in the light of the conditions imposed by the main types of fisheries. In fact, the value of the available methods will vary according to the characteristics of the fisheries, the resources available for management, the efforts which their value justifies, or the legal framework in which they operate. In doing this we shall consider how useful it is to simultaneously:

(a) regulate the fishing rate so as to keep the stock at a high level of production;

(b) reduce the production costs involved in achieving the established management objective so as to maximize the net profits, whatever the nature of the objective which has been set; and lastly

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1/ Fishing mortality, F, expresses the proportion, in numbers, of individuals removed by fishing, C, in relation to the population being fished, N, during a given period of time, e.g. a year

(c) facilitate the application of the regulations, particularly by reducing the motives fishermen may have for evading the law, since problems and costs of application have been a major cause of the failure of management schemes so far.

3.2.1 Catch quotas

This method of regulating the fishing rate is based on the equation:

$$Y = F \cdot B \quad (1)$$

where

Y is the total annual catch
F is the fishing mortality, and
B is the average biomass of the stock.

When natural fluctuations of the biomass are either negligible for the accuracy required, or can be accurately estimated when determining quotas, F can be regulated by fixing a catch ceiling.

This method can be applied in different ways. In its simplest form only the total authorized catch is fixed each year. To the extent that the total catch can be recorded both reliably and quickly (so that the fishing season can be closed as soon as the pre-established quota has been reached), this method makes it possible in principle to preserve the stock at the desired production level. On the other hand, it cannot offset the tendency towards a growth in the cost of catch since each participant is always inclined to increase his catch capacities in order to obtain a larger part of the overall quota or merely to maintain his part. The competition which this method of application allows to persist will have the effect of progressively reducing the fishing season to the point where the weight of the investments and fixed costs will cancel out the net profits produced by the fishery. The specialized literature abounds in examples of progressive shortening of the fishing season in fisheries where this system has been applied (Antarctic whales, season reduced from 121 to 64 days in five years; Gulland, 1974; halibut in the North East Pacific, from nine months to four weeks; Crutchfield and Zellner, 1968), the record probably being set by the North East Pacific herring fishery, fished for roe, where the excess catch capacity is such that the fishing season has been cut down to a period of 15 minutes necessary to each ship to make one seine net cast (Newton, personal communication).

To achieve the disastrous economic effects of such competition, we have naturally come to divide the global quota in national quotas (this was the most commonly used system in the framework of the regional commissions responsible for the main Atlantic international fisheries), by plants (when the entire production passes through a limited number of processing points, e.g., pilchards in Namibia and South Africa; Gertenbach, 1973), by fishing vessels, or even by individual fishermen (herring in the Bay of Fundy, Newton, 1980).

In this way competition between the groups to which the individual quotas are allocated is reduced, leaving it up to these groups to adopt measures enabling them to catch their quota in the best conditions. To eliminate all harmful competition which is liable to persist within groups, we are naturally led to divide the overall authorized catch between each of the individual operators. This leads to the system of so-called individual fishing rights (Christy, 1973).

To the extent that the fishery is not disturbed by other secondary phenomena[1/], the operators in this regulatory framework should themselves try to minimize the costs of extraction of the quota that has been allocated to them and, hence, to maximize the net individual and global profits. If they are satisfied with their share and are guaranteed access to the fishery in equal conditions, we can expect them also to give their support to the application of the system.

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1/ When there are seasonal variations in the price or in availability of the stock, fishermen may be inclined to overinvest so that they can concentrate their operations in the most favourable periods

This system, meeting the three criteria listed at the end of the preceding section, is intended, in principle, to provide a satisfactory solution to the difficult problem of rational exploitation of shared fishery resources. It is designed to create a situation similar to that which widely prevails in agriculture where the peasants as owners or farmers of a well-defined portion of the resource, themselves undertake the basic business of management. However, the two systems are different inasmuch as in agriculture it is the resource itself which is allocated, whereas in the system of individual quotas it is the production.

Unfortunately, this method encounters serious difficulties in application. One of the main ones derives from the natural fluctuations of the stock biomass. The equation (1) shows that in order to be able to control fishing mortality (F) by regulating catches (Y) it is essential that the stock biomass (B) remains stable or that its variations be known. Where the latter are sizable, they are liable to create high costs or serious distortions when quotas are established. Here two situations must be considered:

(a) Seasonal variations in short lifespan species (tropical shrimp, cephalopods, etc.) whose fished phase is mainly composed of a single age class.

For these stocks, catching the same quota is likely to cause very different fishing mortalities depending on how close to the recruitment stage the catch is made. In fact, it will consist of a higher or lower number of individuals depending on the age of the catches. If the fishermen are competing for capture of a single global quota they will tend to concentrate their operations ever closer to the recruitment period, thereby causing a continuous increase in the fishing mortality for the same weight fished. This drawback can be offset, but at the price of making the regulations more complicated, e.g., by dividing up the annual quota into quarterly or other parts so as to ensure that fishing operations are suitably spread over the year.

(b) Interannual fluctuations of biomasses

Several stocks, especially coastal pelagic species, show very wide long-term variations which at present can scarcely be foreseen accurately enough to make full use of the resource. While it is possible to directly measure the size of the stocks by quantitative acoustical surveys, the time periods needed to screen data, analyse the consequences of the quotas that can be considered, and then to select the final quota cannot all be shortened. These periods are all the more critical for coastal pelagic species inasmuch as, due to the shortness of their exploitation phase, the inertia of these stocks is less than, for example, that of many demersal stocks. Thus in the Namibian pilchard fishery, a mere average time of two years between the variations of the biomass and fixing of annual quotas has doubtless led to underfishing in the period of the stock's natural growth and an intensification of overfishing when it was beginning to decline for natural reasons as well. This phenomenon probably contributed to the collapse of the stock which occurred at the end of the 1970's (Troadec, Clark and Gulland, 1980).

Lastly, and this is doubtless the greatest constraint of the quota system when applied to fisheries, the high mobility of fishing operations, the frequent multiplicity of possible landing or trans-shipment points and, even more, the variability of catches make it very difficult, or even impossible at present, to effectively control the whole catches (weight and identification of species) in many fisheries. We shall not deal here with the technical problems of accurate assessment of the quantities fished. This question, although it is sometimes difficult, e.g. in countries which do not have the expertise necessary to develop functional sampling plans, can be solved. The problem of deliberate falsification of declared catch is much more disturbing. In several international fisheries (North Sea, Eastern Central Atlantic, Southeast Atlantic, etc.) where monitoring and control are carried out independently by the national administrations, there is increasing evidence that such practices are becoming more frequent and the falsifications more serious. They are not always due only to isolated fishermen or shipowners; sometimes certain national administrations, caught between the pressures of a profession having to deal with a difficult economic situation because of the lag in adjustment of such capacities to the productivity of the resource on one hand, and the need to defend the interests of the latter in international competition in the other, can be led to join in these practices.

The problem is all the more serious inasmuch as the determination of the fishing mortalities really suffered by the stock and, therefore, the fixing of appropriate quotas depends on knowing the amount of the catch as a whole. The use of catch declarations for the application of management schemes is a cause of false declaration which will not be solved easily as long as fishermen will have no motivation not to evade the restrictions and will not have the conviction, as well as the necessary evidence for it, that their partners are reporting their real catches accurately. It is to be feared that in several fisheries this is simply impossible at present, and that a number of coastal countries are unable to check the accuracy of the reports of their foreign partners (FAO, 1980) any more than that of their own nationals.

Even purely national fisheries do not escape this difficulty any better (Cram, 1981). The recent attempt to apply the system of individual catch rights to the herring fishery of the Bay of Fundy (Canada) is instructive in this connection (Newton, 1980). In view of the very high value of the product caused by the scarcity of herring and related species following the collapse of a large number of world coastal pelagic stocks, it was tempting for some fishermen and fish processors to fish and process quantities larger than the quotas which had been allocated to them. In spite of the fundamental value of the system and the advantage provided by the fact that it was applied to a homogeneous community of fishermen, it was impossible to overcome the practical difficulty of controlling catches. It is possible, but not certain, that this is only a necessary stage to the growth of awareness by the fishermen, who are the ones most concerned, of the conditions required for sound operation of the system.

These undeniable shortcomings should not lead us to reject the system. In the fisheries where the stock is fairly stable and where catches can be controlled[1/], it is likely to provide a practical method for regulation of fishing effort, e.g. application of this method to the surf clam fishery of the east coast of the United States is currently being planned (Christy, pers. comm.)[2/].

3.2.2 Regulation of fishing effort and control of catch capacities

Briefly, this method is based on the following equation:

$$F = {}^{n}qf = {}^{n}qpt \quad (2)$$

where

F is the fishing mortality exerted by a vessel,
q, the catch coefficient, i.e. the fishing mortality exerted for each unit of fishing effort,
f the fishing effort exerted by each vessel,
p their individual fishing power,
t their actual fishing time during the period under consideration, and
n the number of vessels.

It can be seen that in order to control F it is necessary to control the four factors q, p, t and n or, at least, to be able to allow for their evolution.

This equation illustrates the limitations of regulations based solely on regulation of fishing times (fishing seasons, limited number of fishing days or hours per week or per day). These limits are comparable to those described for overall catch quotas (Section 3.2.1); although reducing the fishing time alone can immediately decrease the effort exerted on a stock (at the price, however, of a relative increase in the fixed costs borne by the fishermen), the improvement will only be temporary since the reduction in fishing time is

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1/ Which will be difficult in widely dispersed artisanal fisheries and in those countries, especially developing countries, whose administrative and monitoring capacities are small

2/ One can nevertheless point out that, for a sedentary specie of this type, the direct allocation of the resource (see Section 3.2.3) could be more suitable

bound to be offset by a comparable growth in catch capacities. In fact, the control of fishing times can hardly be justified except in the case of management of work time for social purposes or to temporarily gain time when one has not been able to reduce the catch capacities at the desired time since time is limited by nature.

In principle, it would be sufficient to determine the fishing power of each authorized type of vessel and to limit their number to a level corresponding to the maximum effort sought. This could be done through the issue of fishing licenses (depending on the nature of the fishery and the influence of the different factors in determining the final fishing power) to fishermen, vessels, or for fishing gear (e.g. hooks for longline or trap fishing, length of seine nets, etc.) or a combination of all of them.

In practice, the application of this simple principle runs into various operational difficulties. In fact, the potential fishing power (p) of a fishing unit depends on a large number of physical characteristics of a vessel (tonnage, engine power, fish-finding equipment, etc.) and its fishing gear (trawl, traps, hooks, etc.) as well as the abilities of its crew (FAO, 1976). Now, it is neither possible nor wise to block all the physical characteristics by which a fisherman can improve the fishing power of his boat. First of all, because this would mean foregoing technological improvements and the resulting gains in efficiency. Secondly because, even assuming that this were possible, the fisherman always has the possibility of improving his performances by making better use of the catch methods at his disposal. With a better knowledge of stocks and their movements, of fish behaviour, etc., particularly through an improvement in exchanges of information within the fleet - he can distribute his fishing operations better in time and space and make better use of changes in concentration of the fish. In this way he will exert a higher fishing mortality with the same means and in the same time.

Furthermore, when one or several characteristics of the fishing unit are controlled, the fisherman will try to increase its fishing power by strengthening the remaining free factors (e.g. fish finding equipment). His success will depend on the possibilities that exist for substitution between one or more controlled factors and those left free. Such possibilities will be scarce in a trap fishery where the number and size of the traps will be regulated; they will be considerable in a trawl fishery in which only tonnage or engine power will be blocked.

The schemes to limit fishing effort must therefore recognize:

- that the fisherman has two possibilities, one technical and the other tactical, of increasing the efficiency of his operations and therefore the fishing mortality exerted by the same unit of nominal fishing power;

- that the utilization of these possibilities can be advantageous for the fishery, but that exploitation of the possibilities of substitution to evade the regulations will result in distortions which are costly or even ultimately dangerous for the safety of vessels;

- that the fishermen will make good use of them.

Therefore the regulation plan should be conceived as a dynamic system, i.e. capable of accommodating the desirable development of the factors determining the total actual effort of vessels, while at the same time controlling the fishing mortality exerted by the one or several fleets being managed as a whole. To achieve this it can be based on the fact that in a well established fishery gains in efficiency are often progressive. In assessing them and following up their subsequent evolution, it should then be possible to offset the effects by acting, for example, on the number of licenses issued, and on certain clauses imposed on them (control of factors determining the fishing power). The plan should foresee, in particular, the possibility of transferring licenses from one category of fishing power to another, or from one fishing method to another (since the method can be applied to heterogeneous fleets). As a general rule it will be preferable to have a system with several categories of fishing power in order to allow the fleet to develop and to avoid a sudden increase of the fleet's fishing power when the system is applied. Such an increase would actually be inevitable in the event of a single limit, since all fishermen are inclined to immediately acquire vessels having a power corresponding to the established limit.

To assess the gains of efficiency in each class of vessel and compare their respective fishing powers it will be necessary to monitor the relative performances of the vessels in the different categories. These assessments could be made on appropriately selected samples. It is not necessary, in fact, to ensure total coverage of the whole fleet in collecting catch and cpue statistics, a requirement which is one of the serious drawbacks of the catch quota system. The overall performance (catch, effort) of the fishery taken as a whole could be extrapolated in proportion to the number of licensed vessels, an aspect easier to control in its entirety than catch because it is made up of larger units which are easier to monitor. In application an effort will be made to anticipate the gains of efficiency (changes of q) in order to offset the inevitable delays between the follow-up of the fishery and the fixing of the maximum catch capacity as well as the distortions which influence their relationship.

The serious drawback of this method lies in the difficulty of effectively controlling those gains of efficiency. While various programmes for limitation of catch capacities have managed to slow down growth of fishing effort considerably, those which have succeeded satisfactorily are still the exception. Although this goal has practically been reached, for example in the Japanese high seas fisheries, it must be recognized that for a long time this was accomplished in a context where the catch capacities that had become excessive in the fully developed fisheries could be transferred to other fisheries (Kasahara, 1964; Asada,1973). However, the great advantage of this regulation mechanism is that it directly attacks the cause of overfishing itself. In trying to block investments at the fishing gear level, the overall fishing costs are limited while at the same time keeping the catches at the level considered appropriate for the stock.

The system is better adapted, compared to catch quotas, to prevent overfishing in the event of unexpected decreases of the stock's biomass. The equation (2) suggests, and various simulation studies (Walter, 1976) prove that, at least in the case of demersal stocks,[1/] fishing mortality is kept within narrower limits by blocking catch capacity than by setting limits on the catch. This means that limiting the means of capture is, generally speaking, more reliable from the point of view of conservation of the resource and less demanding as far as its monitoring is concerned. Provided that we have the possibility or the authority necessary for eliminating excess catch capacities, it should be possible to derive substantial profits from them in relation to the research costs necessary for monitoring stocks. Such a characteristic is advantageous in countries having scarce research resources.

Lastly, it can be expected that once the clauses concerning access to the fishery have been adopted (Section 4.1), the fishermen admitted to participate in it will tend in principle to give their support to a system likely to lead to an improvement of their income and to a security and stability they had never known previously. In fact, in several fisheries (sein fisheries in South Africa and Namibia, Gertenbach, 1973; lobster fishery in Western Australia, Meany, 1978) the systems for control of participation were established at the initiative of fishermen's or ship owners' associations themselves.

Although in theory this distinction may not be peculiar to one or the other of the systems examined, we find that in practice the limitation of catch capacities has often been applied to large groups which include several stocks and, perhaps different gear (Japanese tuna fishing, salmon fishing in British Columbia, etc.) in the same management. For example, the licensing system through which Japan administers all its worldwide deep sea fisheries only identified 17 management units at the beginning of the 1970's (Asada, 1973). Contrary to this strategy of concentrating intervention on the means of capture, it has been more frequent to attempt, by the use of quotas, to transpose in management the results of assessments covering stock units smaller than those fished. This practice has two major drawbacks:

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1/ In the case of many coastal pelagic stocks we find an increase of their catchability when the size of the stock decreases: this drop in total abundance is manifested not only by a decrease of density but also by a reduction of its area of distribution or in the number of banks composing it (Saville, 1980)

(a) It does not always take due account of the incompatibility (which can be attributed to the impossibility of fully exploiting stocks fished during the same fishing operations) of quotas set independently for the different stock unit and, more generally, of the constraints appearing at the level of fleets and their operations.

(b) It assumes the existence of administrative capabilities able to handle a group of small management units, whereas such capability is lacking in the majority of countries.

Relatively too much attention has been paid, therefore, to accuracy and detail and not enough to the practicability of measures and their ultimate efficiency. However, the preparation of a catch capacity control scheme should preferably proceed from the whole to the particular and not the contrary, and should successively consider:

(a) the identification of large fisheries which can be administered separately;

(b) the assessment and comparison of the factors influencing fishing power (number and characteristics of gear; some ship characteristics; tonnage, engine power, etc.; number of fishermen; etc.);

(c) the selection, based on those factors, of the elements (vessels, gear, fishermen) and the grid of categories on which the licensing system intended to limit individual and global fishing effort will be established;

(d) eventual establishment of the limits to be imposed on the fishery as a whole and on the categories of boats composing it, with regard to the exploitable stocks and fishing zones. This can be done through clauses attached to each license which will define, in particular:

- the areas and seasons in which fishing is authorized or prohibited;
- the catch percentages which must not be exceeded per year, trip at sea, etc. for certain species which will need to be either permanently or temporarily preserved from overfishing[1/].

The clauses concerning authorized fishing zones and seasons will serve to fix both the resources allocated to each fishery or vessel category and to reduce the conflicts, especially between gear, likely to arise between the different fleets. Thus one would start with a simple overall scheme which one would progressively perfect on the basis of the experience acquired from its application and additional studies.

These advantages should not lead us to underestimate the difficulties of applying this fishing control mechanism. These difficulties (particularly political reluctance as well as the costs of application of the system) will need to be assessed accurately and compared to the benefits to be expected. One will then be able to deal first of all with the regulation of the fisheries likely to produce the largest net benefits.

In analysing these difficulties we must distinguish between those which are specific to the method itself and those which are inherent in regulation of the fishing rate in general. Any management scheme must recognize that the limited character of the resource implies that of its exploitation and, therefore, the regulation of participation in it. The control of access to it will raise the problem of distribution of the net benefits which will be derived from the regulation of fishing. This question will be discussed in Chapter 4; it raises problems which are highly complex at the political and social level, independently of the mechanisms selected to regulate effort.

Management plans explicitly recognizing that a properly administered fishery (as well as the concessions temporarily allocated for extensive aquaculture) will produce an economic

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1/ However, the application of such measures is likely to encounter the same difficulties as those previously described for catch quotas

added value, and that beyond an acceptable level of development it is advisable to prevent the reinvestment of that added value in the fishery, and that this added value should return to the owner of the resource (the State, as the representative of society, or the fishermen; see Chapter 4) are still the exception to the rule. This situation can probably be explained by the fact that, since without management the fisheries provide only a marginal income to the fishermen, the question of removing the added value and, more simply, even the recognition of its existence, for a long time appeared to be politically premature and academic.

However the question is important for the success of the plans itself. First of all, because the clauses on access to the fishery will directly affect the possibility of access by certain socio-professional groups and, therefore, the distribution of incomes among the present or potential operators. These consequences cannot reasonably be opposed to the principle of regulation of access to a fishery. In fact, the evolution of the latter, whether it occurs without management measures or results from incentives adopted in the context of development plans, will have entirely comparable effects on the participation in the fisheries: thus, for example, the development of a trawler fishery could injure artisanal fishery. Secondly, because the assignment of the yield or taxation of it by the State can serve as a basis for the mechanism determining access to the fishery (see Chapter 4). Lastly because, as has been pointed out above, management must prevent the reinvestment of the added value once the level of development corresponding to the selected management objective has been attained; by taxing the added value, the authority responsible for management will make its task much easier; otherwise, the pressures for overequipment and overcapitalization will only be stronger.

The real difficulty of this fishery regulation mechanism lies in maintaining permanent control over gains in efficiency, whether due to technological innovations or improvement of fishing tactics, i.e. in the regular administration of transfers of licenses within the same management unit, from one size category of boat to another and, eventually, from one fishing method to another. More research and experience (which could be acquired from the execution of pilot projects) are needed here. It is important to recognize this dynamic, providing flexible management systems which leave to the fleet its ability to adapt and develop while at the same time being able to control the total effort it exerts. This means that there must be an authority having decision-making powers and the support of the main parties involved in order to withdraw catch capacities which have become excessive. So far these conditions have only been found in a small number of national fisheries (South Africa, Australia, Canada, USA, Japan, Namibia, etc.) (Pearse, 1979; Rettig and Ginter, 1978).

In theory the independence and authority of the central administration will be greater vis-à-vis foreign fleets[1/]. In such cases the national administration has considerable leeway for mobilizing each year the desired number of vessels with appropriate characteristics to attain the established management objective (Doucet, Pearse and Troadec, 1981). This can be achieved, for example, through auction systems enabling the administration to bring the most efficient foreign fleets into competition with one another and therefore likely to submit the most attractive bids and produce the highest income. At present the countries with abundant resources seem to be in a strong position in the negotiation of cooperation agreements, given the excess catch capacities of countries operating long-range action fleets. It is possible that the favourable position of the former may decline once the latter have eliminated these excess capacities. However, there are few fisheries which have recognized the advantages of maximizing such income, whatever the form (in cash or kind) in which it is received and the need, in order to obtain it, to operate at the level of the total fishing effort. This formula for the administration of foreign participation is still far from fully exploited by those countries whose first management objective is the maximization of the net economic income and which do not yet have sufficient catch capacity of their own.

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1/ However, the signing of fishery agreements frequently introduces considerations extraneous to the fishery sector. Thus in recent agreements advantages which are political or economic, but affect sectors outside fishery, have been obtained by certain coastal countries in exchange for access to exploitation of their resources

National fisheries are still far from being able to offer the same mobility either for investments (vessels) or labour (fishermen). So the danger of over-equipment and over-exploitation is even greater. So long as the national fisheries as a whole have possibilities for expansion, transfer from one over-crowded management unit to another which is still in an expansion phase can be applied. For example, Japan was able to redeploy its excess catch capacities and harmonize the development of its deep seas fisheries after the Second World War in this way (Kasahara, 1964; Asada, 1973). When such possibilities are exhausted there arises the thorny problem of withdrawing the catch capacities corresponding to steady gains of efficiency. Although this observation does not provide any solution, it will be noted that the question will arise just as acutely in an unmanaged fishery but that in a well-run fishery the recourse to subsidies to allow the withdrawal of excess capacities will be fully justified by the prospects such subsidies offer for maintaining the fishery in sound economic condition. Furthermore, the cost of such necessary withdrawal programmes should be able to be covered by the added value produced by the fishery. In fact, such measures (buying back licences in order to withdraw excess catch capacities) have already been adopted unilaterally by the profession in a number of Japanese fisheries, demonstrating the value of management for the profession as a whole.

One may wonder why there has not been more frequent recourse to the system of regulation of effort and control of catch capacities, and why the quota system has been mostly applied in international fisheries. It has often been argued that the catch represented a common measure of participation in the fishery; in this sense it would, therefore, be less controversial and so more acceptable to all the partners than fishing effort. However, experience has shown that the possibilities of under-declaration of catches were likely to introduce distortions at least comparable to those attaching to the difficulties of assessing fishing effort. The real reason appears to lie elsewhere: in the international fisheries the parties have never agreed, even implicitly, on long-term schemes for distribution of the resources and participation in their exploitation. In these conditions, i.e., in a competition intended, in principle, to remain open, the means of catch represented the main instrument for countries to defend their rights over the share which they considered should or could be their due. So it was out of the question for the countries to obstruct this mechanism. The respective attitudes of the coastal countries and those operating deep sea fleets, expressed during scientific meetings organized by ICNAF to compare the merits of the two systems, is significant in this respect (ICNAF, 1973). The researchers of the coastal countries advocated regulation of fishing through that of effort; those of the countries operating long-range fleets proved to be in favour of control of catches.

Under the old regime it was tempting therefore, for the partners who were more efficient or better established in the fishery to argue in favour of the advantages of the global quota, justifying it by the shared nature of the resource and the factor of progress represented by competition. At that time the system of a single quota or country quota represented, in comparison with that of limitation of effort and catch capacity, the maximum of what was politically acceptable. Consequently management could not go beyond the simple conservation of resources and, at best, direct sharing of the accepted total catch according to formulas which could be revised each year (Troadec, in preparation). If this explanation was justified, it can be supposed that the legal status of shared fisheries (fisheries based on shared stocks, e.g., those under the responsibility of the European Economic Community) will lead to the adoption of systems providing for the limitation and division of catch capacities by country.

### 3.2.3 Allocation of the resource (biomass)

We have seen (in Section 3.2) that the application of the individual catch quota system to fisheries encountered difficulties. But the advantage of the concept, i.e., that of putting the operator in a position which will encourage him to minimize the costs of his exploitation himself, remains. Where the resource (biomass) itself can be shared between the operators, they should also be able to provide themselves for most of the management and, at the same time, the development of the fishery. This solution has the great merit of considerably reducing the cost and complexity of monitoring for the central authority. Unfortunately, in fisheries the applicability of this method is reduced by the mobility of the species which hinders the allocation of specific portions of stocks directly to the fishermen. There are some stocks, however, above all those whose fished phase is sedentary or scarcely mobile, which afford this possibility. After regulation of the catches and direct limitation of fishing effort, this section briefly describes that third form of management.

The degree to which the stock is sedentary during the fishing phase will directly determine the possibility of dividing up the resource and the responsibility for its exploitation among the fishermen, either individually or in small groups (villages, cooperatives, professional groups, etc.). For the system to be viable, i.e., in order that each fisherman or group of fishermen can be directly concerned with the sound exploitation of his lot, it is necessary that within each lot the exploitation procedures should directly affect the corresponding lot of the resource and its future yields and have relatively little influence on the stock and catches of the neighbouring lots. When these conditions exist, the resource can be divided. This approach is, or was, current practice in several traditional fisheries. In Japan such a system and the allocation of exclusive fishing rights in particular sectors for catch of the more mobile species and for extensive aquaculture are the basis of coastal fisheries management (Herrington, 1971; Asada, 1973). In Brittany (France) the cutting of seaweed was allocated, under customary law, by groups of rocks (Arzel, in preparation). More recently but in the same spirit, the allocation of exclusive fishing rights has been adopted in Italy to control the clam ("vongole") fishery (D. Levi, pers. com.). In Sweden, the rights to fish natural oyster banks were traditionally attached to the landholding on the adjacent coast (Lindquist, pers. com.).

In order to allocate exclusive fishing rights over sections of the resource, the stock need not necessarily be strictly sedentary or sessile. It is enough that the exchanges between the sections be sufficiently small so that the future catches of each fisherman or group of operators making up an exploitation unit should be influenced more by the forms of his own activity than by the exploitation in the neighbouring lots.

In this connection, the example of the management scheme developed by the Maine (USA) lobster fishermen themselves (Acheson, 1975) is instructive. They unofficially, but efficiently, control access to their fishery and have allocated the resource to themselves by dividing among themselves the fishing zone among the villages on the coast. In each village the access to the fishery is strictly controlled by the community itself. At present there are two predominant systems of territorial division: the traditional system by which the fishing territories of each village are strictly limited without much overlapping; the recent tendency, by which the limits are becoming more spread out offshore and some overlapping of fishing operations conducted by each village is accepted on the periphery of the territories. It is instructive to compare the fishing regimes prevailing under each of the two systems and their consequences. We find that, by comparison with what occurs in the more penetrable territories, in the strictly delimited fiefs the fishermen have frequently reduced their individual fishing time by themselves (number of sea trips per year), without it affecting their catches. Furthermore, the comparison of the length frequency histograms of catches taken in the two types of territory show that the stock in the strictly delimited sectors is older on the average, which is an indicator of less intensive exploitation.

Thus the fishermen were able by themselves to:

- unofficially, but in practice, divide up the resource among themselves;
- control the competition between them by regulating access and participation in the fishery;
- limit both individual and total fishing effort; and
- thereby achieve better exploitation of the stock both in biological and economic terms.

To be able to apply this method it is therefore, not necessary that the resource be strictly sedentary. However, the more mobile the species in its fished phase and the larger the area of distribution of the stock, the wider will be the exploitation units that can be managed separately and the higher will be the number of corresponding groups of fishermen. This enlargement of the units will work against the exercise of self-discipline and community behaviour in each group; as the latter increase, the individual motives for competition and discrepancies between individual interests and the common good will emerge. However, even for species which can only be managed as large groups (e.g., small pelagic species), the possibilities of developing responsibility - especially the delegation of a part of the management function afforded by the assignment of the resource to a group of operators should not be neglected.

The distribution, mix and migration patterns of species will thus influence the size of the fishermen's communities able to collectively undertake the management of the stocks concerned, and the extent and terms of the conflicts of interest liable to oppose them to one another. These questions will be analysed in Section 4.2; in fact, given approximately the same scale, the influence of the mobility of stocks on competition between fishermen and the usefulness and conditions of their cooperation arise in the same terms in national fisheries as in those affecting stocks which the countries share.

The regimes under which exclusive fishing rights are assigned (for fishing mobile species) to particular operators (fishermen or communities) in certain fishing zones are often classified under this management system. In this case the rights concern the use of a fixed number of gear (fixed nets, beach nets, rafts to attract tuna, etc.) with specific characteristics. From the administrative standpoint, the system shows marked similarities with that of direct allocation of the resource. The allocation of such exclusive fishing rights in certain demarcated zones is also likely to regulate the fishing rate, result in net profits, and involve the fishermen in management. However, from the point of view of management theory, this system is similar to the system for licensing and regulation of fishing effort described in the previous section. Because of the mobility of the species, there is not, and indeed there cannot be, an allocation of the resource itself nor direct participation of the fishermen in the adjustment of the means and costs of exploitation to the productivity of the resource. The authority responsible for management will always have to fix and administer the number, density, distribution, and the characteristics determining the fishing power of the authorized gear so that the total catch capacities do not go beyond the maximum limit necessary to reach the selected fishing rate.

The allocation of public land in concessions for extensive coastal aquaculture, e.g., shellfish farming or cage production, can perhaps be an intermediate case. In general, at least as much as the site (which is fixed), it is the environment (which is mobile) on which the stock depends (provided to it by the exploiter) for its development; the environment may constitute the basic part of the shared resource. It will then need to be managed by a central authority. Although the sites can usually be allocated to individual operators, the intervention of this authority will still be necessary to determine the density and optimum conditions for use of the sea space and for the preservation of the productivity of this sector (control of pollution, optimal density and distribution of cages and shellfish farming concessions, etc.).

The last point to be considered in the setting up and management of systems for leasing the resource is the determination of the suitable fishing rate and the ability of operators to set in appropriately themselves. For some stocks such as algae, the frequency, intensity and methods of cutting (to ensure good regrowth of the algae) may have been established by experience (Arzel, in preparation). An optimum exploitation rate could then be applied independently by the fishermen. For others, the rate of fishing mortality ($F = Y/B$, equation (1)) is more complex, just as it will be more difficult to fix the procedures for attaining it. Scientific support will be needed to determine these conditions (individual catch quota, age and species selection) of optimum exploitation. Such support will become a normal necessity if the biomass is likely to vary appreciably under the influence of natural factors and the need for yearly adjustment of the regulations.

The management of fishing and extensive aquaculture (originally intended to remain concentrated in the coastal areas) should gradually depend more and more on the allocation of exclusive (but not necessarily permanent) rights to individual fishermen or groups of fishermen over specific geographic sectors. Such assignment can be achieved in different ways, e.g., allocation of the resource itself, fishing licences, fish farming concessions, catch quotas. Since the different types of utilization and exploitation of the biological production of this area are partly contradictory (trawling, artisanal fishing with fixed gear, fish farming concessions, etc., are irreconcilable), the management of extensive fisheries and aquaculture will necessarily have to be integrated. Their application should be handled by the same administration. For the same reasons, basic studies on the methods of allocating resources and the regulation of exploitation of the live material in the coastal sea space, would gain from being conducted simultaneously by the same research institution.

3.2.4 Economic mechanisms for the control of fishing

We have already seen (Section 2.1.2) that all effective control of fishing leads to the production of a net economic yield attached to the intrinsic value of the resource, i.e., of a plus-value being added to the ordinary return on the capital and labour needed for its exploitation. This relationship can be applied conversely, e.g., the fishing rate to which a fishery is subjected can be indirectly controlled by directly removing the added value. In theory, if one removes the income corresponding to the desired fishing rate, the fishery will become stabilized at this level since the overall production costs (including the removal of the added value) will then be equal to the value of the catch.

In practice, it is difficult to employ such a mechanism directly on a national unmanaged fishery in order to improve it. Economically and politically, the temporary increase in costs and the simultaneous reduction of employment which is involved in the reduction of effort necessary to that improvement will not be acceptable to the fishermen. On the other hand, one can envisage setting up such a system by covering the excess costs imposed on the fishermen during the reconstruction phase of the fishery. Once the fishery has been brought back to the desirable level of exploitation this intervention mechanism will take full effect.

The added value can be removed:

- either before the catch is taken, in the form of a fee to be paid in order to obtain the fishing licence, the catch quota or the section of the resource;

- or after the catch has been taken, in the form of various taxes and duties or price control imposed on the fishermen.

In the first case, after having determined the optimum level of catch one could either fix the fee giving the right to fish each section of the total catch at an amount corresponding to the estimated amount of the added-value, or else, by a bidding system, allow the total amount of the fees to become established at the level of the earnings. The latter formula, which is more flexible, seems in principle well adapted to handle the participation of foreign vessels; if there is enough competition the more efficient ships will be in a position to make the most attractive offers. This method should make it possible to increase the income not only by regulating fishing effort, but also by mobilizing the vessels which are the most efficient and therefore, most likely to make the catches established at the lowest cost.

From a psychological point of view, it is much more difficult to collect the added-value from the fishermen after they have made their catch. Nevertheless it can be collected if the fishermen are not actually paid the income. In the planned economy countries, the State can regulate the fishing rate by control of the unit prices paid to the fishermen. In this way a resource rent is extracted; it will be expressed in the form of a low-cost protein supply to the population. Christy *et al.* (1981) give a good example of taxation imposed indirectly on the skipjack tuna fishery in the Maldives which, together with tourism, constitutes the main resource of the country. Most of the production is exported. The Government handles the marketing. By applying the official rate in local currency at the time of purchase, the Government only pays the fishermen about half of the actual export price. It is thus able to directly collect the added value which it uses in practice to subsidize the import products of prime necessity (cereals, babyfood, marine engines for fishery, etc.); in the other direction, this is done by applying, the official rate of local currency in calculating the local selling price of imported products.

4. ALLOCATION OF RESOURCES

Regulation of fishing, which is made necessary by the limited nature of fishery resources, also implies a control of the participation in fisheries and the distribution of the riches produced by their exploitation. There are those who dispute this statement in the name of free enterprise or the shared nature of fish stocks. They are especially opposed to the concept of limited entry[1/] and the regulation of fishery by the issuing of

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1/ "Limited entry" in the English language literature

a limited number of fishing licences, arguing that its application might create a monopoly situation for the fishermen to whom a licence is assigned. Stated without any other explanation, this assertion perpetuates a confusion between a right in principle - for example, that every citizen could eventually take part in the national fisheries - and certain quite real contingencies, i.e., that the number of fishermen for whom a national fishery resource can provide a livelihood is limited, and that fulfilment of national fisheries development and management objectives depends on the establishment and application of provisions fixing the conditions of access and distribution of profits between the operators as well as between them and society. In the preceding chapters we have given several examples of the often harmful effects on the economic condition of fisheries, employment, individual income of fishermen or the transfers of income between different groups of fishermen, caused by a lack of explicit decisions in the management field. It would be preferable, to have effects deriving from explicit well-reasoned choices rather than implicit consequences. The situation is not peculiar to fisheries. In agriculture, for example, the increase of the number of farmers, if they do not have the necessary mobility, can result in excessive reduction of the individual planted area and can require the intervention of the authorities. Thus the term "limited entry" lends itself to confusion, i.e., it is not the access of one or another particular potential operator which should be prohibited, but the number of fishermen who would benefit by being controlled. Only, in fisheries the shared nature of the resource makes the need for intervention of the central authorities greater if one wishes to fully realize the possibilities offered by this sector of the economy.

## 4.1 National Fisheries

### 4.1.1 Resource distribution within the same fishery

The problem raised by allocation of resources is both political and technical. In the end, it is a question of deciding how the net profits derived from fishery are to be distributed between present and potential operators, between capital (vessels) and labour (crews), between the producers and the consumers, and lastly, between the fishery sector and the national economy as a whole. At the technical level, mechanisms must be developed which will allow the application of the distribution schemes selected; if what matters ultimately is the distribution of the net profits, it will be necessary to determine whether this can be done better by dividing the resource itself, the means of fishing, the catch itself or even, directly, the added value, and the implications of the choice of one or another of these mechanisms for the sharing of the net profits.

The distinction between the political and the administrative function of management is fundamental, even though it is not always fully appreciated, since decision-making is frequently identified with the administrative function. The two tasks can only be merged operationally when decisions can be adopted by reference to at least an implicit consensus on the assignment of the resources and the present or potential profits of their fishing. Whenever a reference frame for the decisions to be adopted does not exist, or the equilibrium accepted until then by the parties concerned is challenged, recourse to political mechanisms and political authorities becomes necessary. For example, the decision adopted during the summer of 1980 by the shipbuilders of Boulogne, France, to reduce the number of crew members to compensate for the increase of gas oil prices resulted in a strike, a conflict which could only be solved by recourse to the political process. This observation applies both at the national level (division among various fishermen's or socio-professional groups) and the international level (shared stocks).

Ideally, the policies to be established and gradually perfected should meet three conditions; i.e., they should:

- maintain fishing rates at the level corresponding to the selected management objective;
- extract the corresponding net profits and ensure that they be divided according to the policies chosen;
- facilitate implementation.

Furthermore, these sharing and management schemes should neither delay technological improvements that could lead to gains of efficiency nor inhibit individual initiative.

Finally, they should reduce the danger of arbitrary action or collusion when rights of access are assigned to fisheries. The mechanisms for allocation of resources which respond to these criteria are built around two fundamental choices.

The first acknowledges that the fishery resource, as well as the public land that can be allocated to aquaculture enterprises, belongs to society. In that case the State assigns temporary exploitation licences to fishermen in order to allow a periodic review of allocation schemes and eventual replacement through the entry of new participants. These schemes may acknowledge preferential rights to certain socio-professional categories. Thus, to compensate the frequently lesser mobility of manpower and investments in artisanal fishery, or to take account of the need to launch development programmes which can directly benefit the most deprived population sectors when redistribution of wealth is inadequate, one could recognize that fishermen should have priority of access to fisheries as well as in the development plans for extensive aquaculture in littoral areas. Likewise, to preserve and fully utilize the better knowledge and understanding of the natural area which provides their livelihood, one could recognize that, where offers are equal, the fishermen already participating in the fishery or exploiting aquaculture concessions should have preference over new candidates. In that case the licences will be issued for long enough periods to enable the investments granted to become profitable. The duration of these periods will be determined according to the mobility of the investments and labour, i.e., they will be long (e.g., a decade) in the case of national fisheries, and decidedly shorter (e.g., one year) in that of long-range foreign fleets allowed to operate in the zone of jurisdiction of a coastal country.

The second option consists of acknowledging that the resource belongs to the fishermen participating in the fishery. In that case, the licences correspond somewhat to shares in the resource; they can therefore, be transferred or traded on the basis of the commercial value they acquire as progress is made in its management.

In fact, the value of fishing licences will tend to become similar to that of the income created by control of the fishing. If it is accepted that the resource is owned by the State, but if the latter grants the fishing rights free of charge, the authority responsible for management will be subject to considerable pressure when assigning them. That is why it is better to depend on market mechanisms, supplemented when necessary by clauses designed to protect those rights, historical or otherwise, and to reduce the main handicaps in some communities or socio-professional groups. Thus one can have recourse to a system of bidding for their allocation, provide for their free transfer so that the fishermen can resell them freely to one another and, eventually, have a certain number of them repurchased by the administration to compensate for gains in efficiency or to eliminate excess capacities in fisheries that are initially over-exploited. These transactions will be conducted on the basis of the sales value of the licences determined by the market.

To prevent undesirable transfers in the distribution of wealth, or concentrations or monopolies because the market mechanisms might not operate satisfactorily, it might prove desirable for the central administration to preserve some right of intervention. This will be the case, for example, when local populations do not enjoy the same capacity to mobilize capital and the new technologies necessary for full development of the coastal resources which they traditionally exploit. In that case, emergence of new methods of exploiting the resources (industrial fishery in the developing countries, new forms of extensive aquaculture, etc.) could attract new operators having the advantage of higher efficiency and therefore, partly exclude the traditional fishermen who are handicapped at the outset by insufficient mobility and reduced alternatives.

In practice, the question of ownership of a resource and the value attaching to it is seldom clearly recognized. This is due partly to the fact that plans for control are often applied at first to already overexploited fisheries in which the value of the yield is practically zero. The licences are then granted, without any time limit, to all or almost all the fishermen present in the fishery at the time. This practice is equivalent to making the fishermen present when participation is restricted to the owners of the resource, and assigning most of the economic yield to them, since their successors have to buy the right to fish from them at a value corresponding to that yield.

This practice does not expressly foresee the periodic renewal of the licences, a measure which greatly facilitates the State's collection of the income produced each year

by a national natural asset, the periodic adjustment of catch capacity to the productivity of the stock, and the eventual replacement of some operators by new ones who might improve the profitability of its exploitation. When licences are granted for long periods, the plans should provide for the yearly renewal of the rights of a part of the fleet that will be equal to all of it divided by the number of years for which the licences are valid, so that the administration may regulate the total catch capacity by successive small adjustments without any delay.

Finally, it will be noted that the payment of the income by the State through recourse to market mechanisms, or even making ownership of the resource private, and transfer of the rights of ownership by the same mechanisms, will not in principle directly improve the average individual income of the fishermen. This can be acceptable when fishermen enjoy mobility to leave the fishery comparable to that available to the other economic sectors which could receive them. That is seldom the case in the traditional fisheries, especially in the artisanal fisheries of developing countries (Panayotou, 1982). In a fishery in bio-economic equilibrium where the extraction of the earnings will be added to the costs borne by the operator, the average individual income of the fishermen will not depend on regulation of effort but mainly on the measures adopted to increase his mobility (creation of new activities) or on the assignment to the operators of part of the earnings. State intervention will be needed to attain this. Since the fishermen's support for the application of management schemes will depend on the benefits they can derive from those schemes, the progress of management could depend on the preparation of schemes enabling them to receive part of the earnings produced by the improvement of the fisheries. The improvement of their income should in turn increase their mobility.

4.1.2 Competition amongst different fleets for the same stocks

There are many examples of conflicts of this type. They can arise between different socio-economic groups (artisanal fishery and industrial fishery, commercial and sport fishing, etc.), different methods (seine net and pelagic trawl, for example), or different utilizations of the resource and the environment (shellfish farming and pollution). These conflicts are not confined to catching the resource. They can be expressed in terms of fishing operations, e.g., fixed gear-fishing (long-lines, driftnets, traps, etc.) is physically incompatible with trawling. This kind of conflict can be settled by allocating different sectors of the fishery to each fishing method. Very often a coastal strip of varying width is reserved for artisanal fishery in order to allow for its small range of action and scarce mobility. Such measures influence schemes for sharing the resources between different groups of fishermen, and their development. They increase the cost of fishing for fishermen whose more efficient fishing operations are restricted and cause the administrative authorities expenses and difficulties of application which may simply make them not worthwhile. But these costs may be completely justified in social terms, at least temporarily, in order to protect certain social groups which are at a disadvantage in regard to mobility, access to resources or markets (Section 2.2.1), or to maintain the employment level in certain sectors where there are few alternatives.

Conflicts among fisheries can also be expressed in the competition for markets. Thus, the development of commercial fishery and recourse to imports have had harmful effects on the development and the economic condition of artisanal fisheries in several countries of the Gulf of Guinea (Longhurst, 1969) which have been unable to produce at the same prices.

We shall see in Section 4.2.2 that under the new regime of the Law of the Sea the competition between countries jointly owning the same stocks is set in comparable terms. In view of the segregation now imposed on operations of national fleets by the establishment of exclusive economic zones, the patterns of distribution, mix of individuals within each stock, and migration with age directly affect the terms of this competition.

However the problem will arise more frequently and with more complexity at the national level, first because the number of shared stocks will increase in inverse proportion to the range of operation of the different fleets concerned, and secondly because conflicts within the national fisheries will involve a larger number of factors. The grave conflicts now opposing artisanal and industrial fisheries in many countries, in particular in Southeast Asia (Panayotou, 1982), demonstrate this. Contrary to the philosophy of free competition which formerly prevailed in international fisheries where access and the location of fishing operations remained free, these present or potential conflicts can no longer be ignored by the national administrations. In fact, in this competition the parties are not on an equal footing. As the example of Ivory Coast shrimp fishery (Section 2.2.1) has

shown, lagoon fishery enjoys a dominant strategic position because it exerts activity on a juvenile phase. On the other hand, while the efficiency of artisanal fisheries in terms of catch per unit of investment or through the quantity of fuel consumed is generally higher, they are often handicapped by less labour mobility, poor capacity to mobilize capital and technological innovations, wide dispersion of landing points and their consequences for the placement and marketing of the output (Panayotou, 1982). The national administrations cannot ignore these disparities.

The final decisions will continue to be of a basically political character, since they determine the way certain national assets will be divided between different socio-professional groups. The authority conferred on States to administer the fisheries in their own exclusive economic zones has at the same time increased their responsibilities. Such authority concerns not only the activities of foreign fleets liable to operate in their exclusive economic zones, but also extends to the national fleets. The possibility of controlling the operations of foreign fleets, as well as their effects on the performances of the national fisheries, eliminates an argument that in the past was sometimes advanced by various national administrations (and not always justifiably) to excuse the insufficient attention paid to the management of their national fisheries and to effective application of the appropriate regulations to them.

## 4.2 The Particular Case of Shared Stocks

The legal regime of the seas which is currently being established constitutes the first partly successful attempt to reduce competition between countries for exploitation of shared fishery stocks. The existence of an agreement on the international sharing of resources and the distribution of the authority necessary for their sound exploitation may now enable the coastal countries to regulate fishing and thereby to realize the economic and social benefits which until now were only latent in most fisheries.

However, there is a group of stocks whose size varies depending on the regions, for which the whole problem of rationalizing their exploitation remains to be solved. These are stocks which are spread over more than one exclusive economic zone, as well as beyond the 200 mi limit in the open seas. The chances of being able to apply the different plans and mechanisms described in the preceding chapters to these stocks will continue to be slight as long as the countries concerned have not agreed on principles for long-term distribution of the potential benefits which can be produced by the fishing of these stocks, and, hence, for sharing the authority needed for their management.

The new law of the sea has two consequences for the management of these multinational stocks:

- the number of countries responsible for their management is small (except where stocks in the high seas, mainly tuna and whales are concerned);

- even more important, the operations of their respective fleets will be restricted, unless otherwise agreed, to smaller geographic sectors established inside the distribution and migration area of the stocks. Whereas under the old regime governing international fisheries, fishing vessels could make their catches anywhere in the open zones, the catches of each country will now often include different phases of the lifespan of the individuals constituting each stock. These restrictions imposed on the location of fishing operations have significant implications for possible schemes for sharing resources.

### 4.2.1 Base data which may be useful in drawing up of concerted schemes for exploitation and management of shared stocks

Under the old regime when the countries agreed on the need to set quotas on their catches, the jointly adopted division of the total catch was usually based on the national catches obtained previously. Distribution formulas were adopted giving different weights to the recent and earlier catches; these formulas were eventually corrected to take into account the specific needs and recognized rights of certain categories of countries or fleets, i.e., those which had recently entered the fishery, coastal states and short-range fleets, developing countries, etc.

For countries linked by particular affinities, common interests or history, past performances can always supply relevant elements of information for the negotiation of their agreements. For example, during the Fourteenth Session of the FAO Committee on Fisheries (FAO, 1981a), Norway mentioned this fact as one of those which had been considered during its negotiations with the USSR. However, this outlook is far from being the general rule. Past performances have little chance of constituting a basis for negotiation when the countries are separated by disparities of development. The new regime partly reflects the less developed countries' rejection of advantages acquired in the course of history by a minority of economically and technologically more advanced countries. These gaps are very likely to influence the management objectives of countries. For example, Mexico sees the share of the anchovy stock assigned to it in front of the California peninsula as the basis of an industry intended to provide it with revenues, new jobs and considerable related economic advantages; but to obtain all of these it must bring its annual catch to quite a high level. On the other hand, the State of California (USA) has so far viewed its share of the same resource as the food base of a stock (bonito, swordfish, barracuda, mackerel, etc.) mainly of interest to its sport (of major economic importance) and commercial fisheries. Until now therefore, its management has been based on the adoption of catch quotas representing only a small proportion of the maximum anchovy stock catch potential.

Whatever importance the countries will decide to attach to these considerations and to the aspects outside of fishery when negotiating their cooperation, these questions lie outside the framework of the present study whose purpose is to analyse the constraints imposed by the characteristics of the resources and their fishing on the application of the new regime and the kinds of information needed to serve as a basis for the preparation of agreements. Because of the new conditions which the new Law of the Sea imposes on the geographic location of the fishing operations of different national fleets, the distribution, mix and migration patterns of jointly owned stocks are bound to have a marked influence on:

- the need for cooperation;
- the stages of joint planning needed for preparation of exploitation and management agreements;
- the contents of such agreements.

4.2.2 Patterns of distribution and migration, and management of shared stocks

Three aspects of distribution and migration patterns are likely to affect the requirements and procedures in matters of cooperation between coastal countries concerned by the exploitation and management of the same stocks (Gulland, 1980; Caddy, 1982). These are:

- the size of the distribution areas of stocks in relation to the geographic division of zones of national jurisdiction;
- the intensity of intra-stock exchanges across the frontiers marking the exclusive economic zones;
- the types of stock movement and, particularly, whether or not they affect the stock as a whole or, by acting differently, the different age classes constituting it.

Table 2 gives examples of stocks classified according to these three factors.

The geographic distribution of stocks will determine those which are shared and the countries jointly concerned by their exploitation and management. Among the former we shall distinguish the multinational stocks confined within several EEZs from those which are also fished freely on the high seas, i.e., adjacent stocks (demersal stocks on the Flemish Cap and the southwest front of the Grand Banc, Northwestern Atlantic) and the deep sea migratory stocks (whales, tuna). In doing so we must bear in mind that the boundary of the stocks is not clearly defined, with some densities which are too low to be exploited extending well beyond the fishing grounds. Likewise it must be remembered that stocks are not stable either in time, nor in their absolute abundance or geographic distribution (Section 2.1.1). Furthermore the list of countries concerned and the share of catches which could go to each of them will have to be reviewed at regular intervals. For example, with the increase and

Table 2

Main distribution, internal mix and migration patterns classified according to their effect on the needs for sub-regional cooperation and the possible forms of sharing (see Section 4.2.2)

| Displacement patterns | | Distribution Patterns | | |
|---|---|---|---|---|
| | | A. National | B. Multinational | C. Multi/International |
| | country — coastline<br>EEZ — 200 miles<br>high sea | X Y Z | X Y Z | X Y Z |
| 1. Stock consisting of sessile or sedentary individuals (exploitation phase) | | A.1 - Seaweed, bivalves and other molluscs, some crustaceans (spiny lobster, crabs), reef fish, etc. | B.1 - Seaweed, bivalves and other molluscs, some crustaceans (spiny lobster, crayfish), reef fish, etc. | |
| 2. Random individual movements along the coast (across the borders of inter EEZ) | | A.2 - A few tropical demersal species with uneven distribution, e.g., West African croaker (*Pseudotolithus elongatus*) attached to river mouths | B.2 - Various tropical demersal stocks, e.g., West African bass (*Pseudotolithus senegalensis*); anchovy off the coasts of Chile and Peru (see Fig. 9) | C.2 - Skipjack tuna (*Katsuwonus pelamis*) |
| 3. Movement with age | Nursery ↗ ↘<br>spawning area ← feeding area<br>(see Fig. 9) | A.3 - Tropical penaeid shrimp | B.3 - Tropical penaeid shrimp | C.3 - Salmon, various species of tuna (yellowfin tuna, bigeye tuna) |
| 4. Seasonal migrations (adults) | Nursery ↗ ↘<br>spawning area ← → feeding area<br>(see Fig. 10) | A.4 - West African bonga (*E. fimbriata*), etc. | B.4 - West African bonga, round sardinella, horse mackerel, West African mackerel, etc. | C.4 - Whales, Northern bluefin tuna, striped marlin |
| 5. Long-term fluctuations<br>- stock distribution and abundance<br>- specific composition of the ecosystem | | | B.5 - Most coastal pelagic stocks (Japan, Namibia, Peru), etc.<br>- Moroccan sardine<br>West African triggerfish (*Balistes capriscus*) | C.5 - Horse mackerel |

extension southward of the Moroccan sardine stock, Mauritania has become the recipient country in the management of this stock. The changes in the species composition of ecosystems generally affect much larger geographic areas. Thus, the sharp increase of the trigger fish (*Balistes capriscus*) stock in the Gulf of Guinea affects all the coastal countries from Angola to Mauritania (Troadec and Garcia, 1980).

The mix rate within the stock will determine the potential value of the operation and the benefits which the countries can expect to derive from their cooperation. For example, the advantage of getting together to work out and apply joint management schemes will be zero for stocks whose fished phase is sedentary or scarcely mobile (seaweed, many molluscs probably including several demersal cephalopod stocks, certain shellfish, spiny lobsters and lobsters, reef fish; displacement pattern 1 in Table 2), unless it appears necessary to preserve recruitment. This could be the case of certain spiny lobster stocks whose larva phase takes place at sea and whose recruitment in an exclusive economic zone could be affected by the fishing and the size of the resulting adult stock in other economic zones.

For stocks whose fished individuals only make undirected displacements from one exclusive economic zone to another, so that their exchanges from one zone to another remains slight (anchovy stock of Chile and Peru; pattern 2, Table 2, Figure 9), there is little need for cooperation. The existence of sizeable bathymetric displacements with age (i.e., perpendicular to the coast) does not necessarily alter this observation. It is enough that the migrations parallel to them remain moderate so that each exclusive economic zone contains a complete section, in terms of age classes, of the population, which continues to be practically independent of the exploited sections in the adjacent economic zones. In the present state of information, this pattern seems to be frequent in tropical demersal fish species. For example, Troadec (1971) considers that the countries bordering the Gulf of Guinea can apply unilaterally formulated regulations to their coastal trawl fisheries with the hope of obtaining substantial results.

This observation is important because it is always easier to decide and act alone, especially when the decisions adopted jointly and their observance could affect the performances of national fisheries. This does not mean, in this as in the preceding case, that there is no advantage in cooperation. The countries fishing the same stocks often have to face similar problems of research, development and management. The organization of periodic exchanges of information and experiences, as well as the harmonization of programmes for study and experiment, are most likely to be of mutual benefit.

Finally, the type of displacement of stocks as well as our knowledge of it[1/] will influence the procedures for sharing the resources. When we are dealing with stocks in which the individuals only make or seem to make random displacements, i.e., when the individuals seem to be uniformly distributed, whatever their age, over the whole distribution area, the negotiation of the forms of sharing could be based on maps of average density of the stock (over the year) and of its whole distribution area. Recourse to this type of information comes down to recognizing that schemes for sharing the resource can be based on the geographic distribution of the average production of the stock among the various zones of national jurisdiction. The average biomass whether absolute or relative will then provide an index of stock production and the maps for this index will serve to determine its geographic distribution. The catches per unit of effort derived from biomass prospecting campaigns (by trawling, for example) or commercial fishery statistics such as measurements of absolute biomass (by quantitive acoustic prospecting, in particular) could be used to draw up such maps. Tagging campaigns, if their cost and the complexity of conducting them do not exceed the gains expected from better sharing agreements, could also supply data of fundamental importance, particularly on the extent and rates of mix between adjacent economic zones. At a meeting held in Dakar in June 1979, the countries of the CECAF[2/] North Sector (Cape Verde, Spain, the Gambia, Guinea, Guinea Bissau, Morocco, Mauritania, Senegal and Sierra Leone) recognized the usefulness of such types of information for an

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1/ In the absence of information on the quantitative aspects of distributions and migrations, we could accept the hypothesis of a homogeneously distributed biomass. Later on we shall change the formulas for sharing calculated on the basis of this hypothesis as data are acquired on the distribution and migrations of these stocks

2/ Fishery Committee for the Eastern Central Atlantic, FAO

initial analysis of possible formulas for sharing the production of coastal pelagic stocks (sardine, sardinella, mackerel, horse mackerel) which they control jointly (FAO, 1979), and some of them based their positions on these elements of information when negotiations were later conducted on this subject (Sub-Regional Conference on the Preservation, Conservation and Exploitation of Fishery Resources, Nouakchott, Mauritania, May 1980). Norway also took these principles as a basis to prepare the points of negotiation of a resource-sharing agreement with the European Economic Community.

The complications arise when the stock migrates, since then the stock's production in the different parts of its distribution area will depend not only on the average biomass present but also on the average age of the individuals composing it. Unfortunately, the respective contribution of the different components of the stock (breeders, juveniles, eggs and larva) to the production of the stock as a whole cannot be established objectively.

Patterns 3 and 4 of Table 2 correspond to situations in which as the stocks grow older they make clearly defined migrations, whether across exclusive economic zones or not (Figure 10). In the first case, individuals only make one migration cycle (nursery - feeding area - spawning ground) during their lifetime; they generally die after spawning, which in that case occurs only once (penaeid shrimp, cephalopods, salmon, etc.). In the second case the situation becomes complicated, i.e., an annual seasonal migration cycle between trophic and spawning areas, is superimposed on the preceding pattern. The latter pattern is very frequent in fish; examples where these migrations can be of greater or lesser scope are provided by the anadromous stocks like West African bonga (*Ethmalosa fimbriata*), coastal pelagic stocks like the round sardinella in West Africa (Figure 11) and, for ocean species, striped marlin (Figure 12).

In these circumstances, one way to envisage the preparation of possible sharing schemes is to see how and to what point the countries can harm one another by increasing their catches in their own exclusive economic zones, and only in those. In short, a country is liable to injure the production of a neighbouring country fishing the same stock in two ways:

(a) If it has the opportunity to intensify the fishing of cohorts before the latter are accessible to vessels of the second country, its fishery will then reduce the recruitment of a section of the stock exploited by the latter country. This situation corresponds quite closely to the Soviet-Norwegian cod fishery in the Northeastern Atlantic. The young age classes are most abundant in the Soviet zone where recruitment takes place after the eggs and larva have floated from the Norwegian coast where spawning occurs. This situation can be compared, although without seasonal migrations, to that describing tropical penaeid, shrimp (see Section 2.2.1) when their nurseries are in the lagoons of one country and the concentration of adults occurs off the coasts of a second country.

When a country is thus able to exploit the cohorts before its neighbour, it is in a position of strength since it can reduce the yields of its neighbour without the latter being able to use the same method to damage it. Faced with this situation, Norway invited the USSR to come to Norway's own exclusive zone to capture part of its catch quota which had been established by common agreement. Norway expected to ensure in this way that the Soviet quota should be composed of individuals older on the average, which would have made it possible, with the same catch quota, to decrease the fishing mortality inflicted on the whole stock in general and the section accessible to the Norwegian fleet in particular. If we consider only the damage which competitors can theoretically do one another by intensifying their fishing of already recruited cohorts (i.e., apart from any possible retaliation through a reduction of the general recruitment of the stock), one can suppose that Norway would thus be inclined to offer the USSR compensation that could approach the amount of the damages, the latter is in a position to inflict on it due to the strategically favourable location of the Soviet fishing operations.

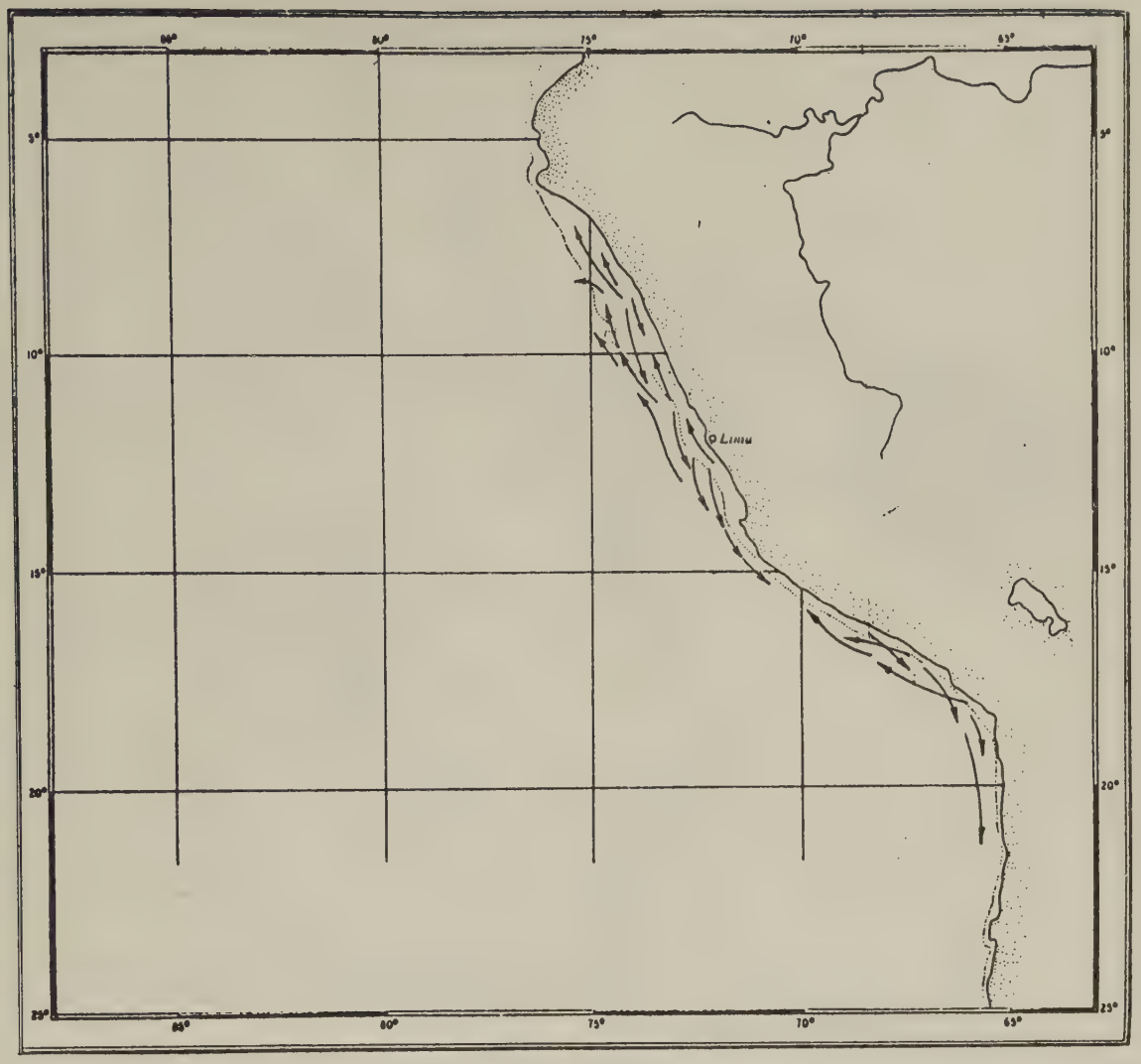


Figure 9 Southeast Pacific anchovy: area of distribution and migration as can be deduced from tagging experiments; a cut-off in distribution and internal mixing seems to appear at the level of latitude 15°S (according to FAO, 1981d). This observation and the small area of the displacement of individuals will make it possible to plan independent management schemes of separate sectors of the distribution area of the species, i.e., North and South of latitude 15°S

(b) By reducing the overall recruitment of the stock through overfishing of adults as well as juveniles, so that the breeding section of the stock may be reduced to a level where its average recruitment may be affected negatively. In this situation, the fisheries of all the countries exploiting the same stock (including those of the country or countries which would be responsible for excessive fishing) will be affected by that overfishing. In this case the possibilities of reprisal are shared better, whether the overfishing is exerted early or late in the life of the cohorts.

While in the first situation the effects of an intensification of the fishing will be felt immediately and directly on all the older fisheries, the effects of the second phenomenon will be deferred and much more diffuse and difficult to identify. In any case, it is in the interest of each country to determine what sections of the stocks it exploits are concentrated in its exclusive economic zone as well as in those of its neighbours, and in what way and up to what point each of them can injure the others.

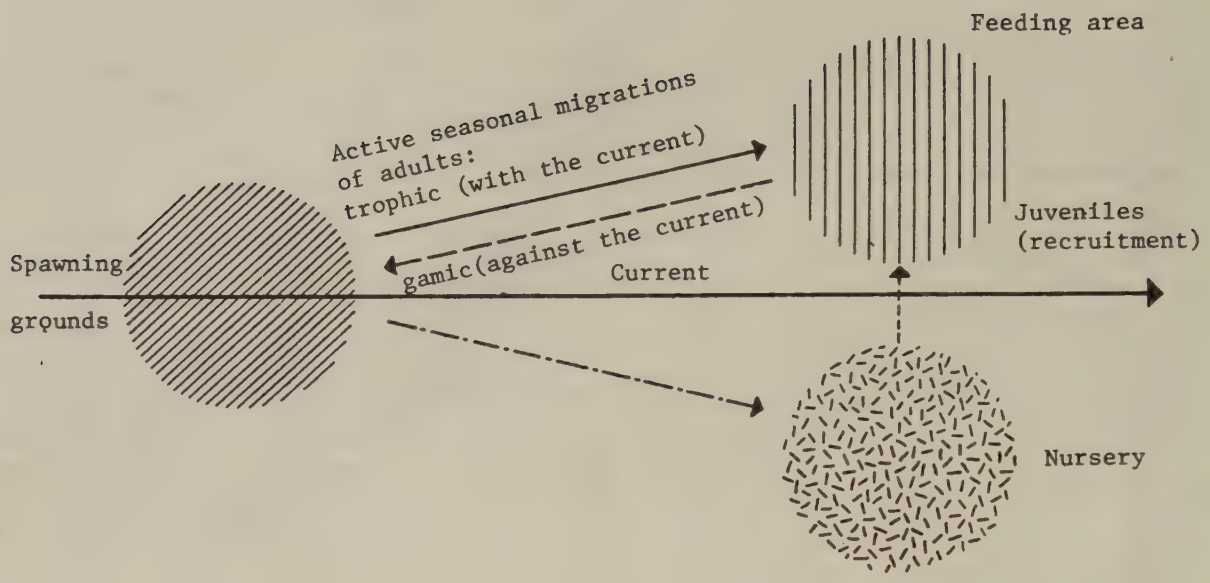


Figure 10 Simplified pattern of fish migration: two cases must be considered:

(a) that in which the adults make seasonal migrations between the feeding area and the spawning ground

(b) that where the specie dies after first spawning (salmon, penaeid shrimp) or do not make any clearly defined seasonal migrations (see text) (from FAO, 1981d)

These are not the only factors that are likely to influence cooperation schemes. The geographical and seasonal changes in the availability, as well as in the quality, of the fish may directly influence both the cost and value of the catches. This is important, since the distribution among the operators of the net profits produced by the fishery is ultimately more important than that of the mere weight of the catches.

Seasonal migrations in particular, can cause marked variations in the availability of fish. Thus preliminary estimates suggest that pelagic trawl fishery of coastal pelagic stocks (sardinella, horse mackerel, mackerel) would cease to be profitable at the present exploitation rate if the trawlers had to limit their operations to the Mauritanian exclusive economic zone, without being able to follow these stocks in their winter migration to the south or turn to other types of fishing during the dead season (Doucet, Pearse and Troadec, 1981). The signing of reciprocal fishing agreements, under the terms of which the countries sharing the same stocks would open their frontiers to allow their respective national fleets to fish the share assigned to them in the more favourable sectors of the stock distribution area, constitutes another promising field of regional and sub-regional cooperation. It has received little attention so far, probably because the countries are anxious to first assert their authority over the resources which they control and not to adopt hasty decisions concerning the procedures for exploitation of the stocks they share. Besides encouraging the full utilization of investments and substantial economies, such reciprocal fishing agreements, through the direct contacts they involve between national fleets, enable each country to judge better to what extent its partners are adhering to the jointly accepted regulations.

Figure 11 West African sardinellas: hypothetical patterns of distribution and migration inside the exclusive economic zones of the coastal countries. The existence of clear, long range seasonal migrations complicates the problem of sharing the resource between the countries that are the joint proprietors (from FAO, 1973)

The reduction of the number of parties concerned by the exploitation and management of each shared stock and, especially, the specific restrictions now imposed on the location of the operations of each national fleet therefore upset the terms of the competition for the fishing of shared stocks. The much more specific consequences, regarding the nature and extent of the damages which the countries can now inflict on one another, could ultimately accelerate the signing of mutually acceptable agreements, although possibly only after each competitor, in the course of a period of fairly intense competition, could become convinced of his real possibilities of increasing the part which could be assigned to him, as well as his partner's possibilities of opposing it. Insofar as the necessary data are available, it should be possible to simulate the consequences of the different scenarios of foreseeable competition and thereby to give the interested parties estimates of the damages they could inflict on themselves. These analyses could help to bring the points of view closer and to encourage the conclusion of negotiations on schemes for sharing and cooperation, so that costly competition could be cut down.

To conclude this chapter, it will be recalled that these considerations concerning the influence of distribution, mix and migration patterns on management of shared stocks apply directly to problems of competition and conflict between different fleets or groups of national fishermen (parallel zoning of the coast to protect artisanal fishery from damages caused by the encroachment of trawl fishing or strips perpendicular to the coast assigned

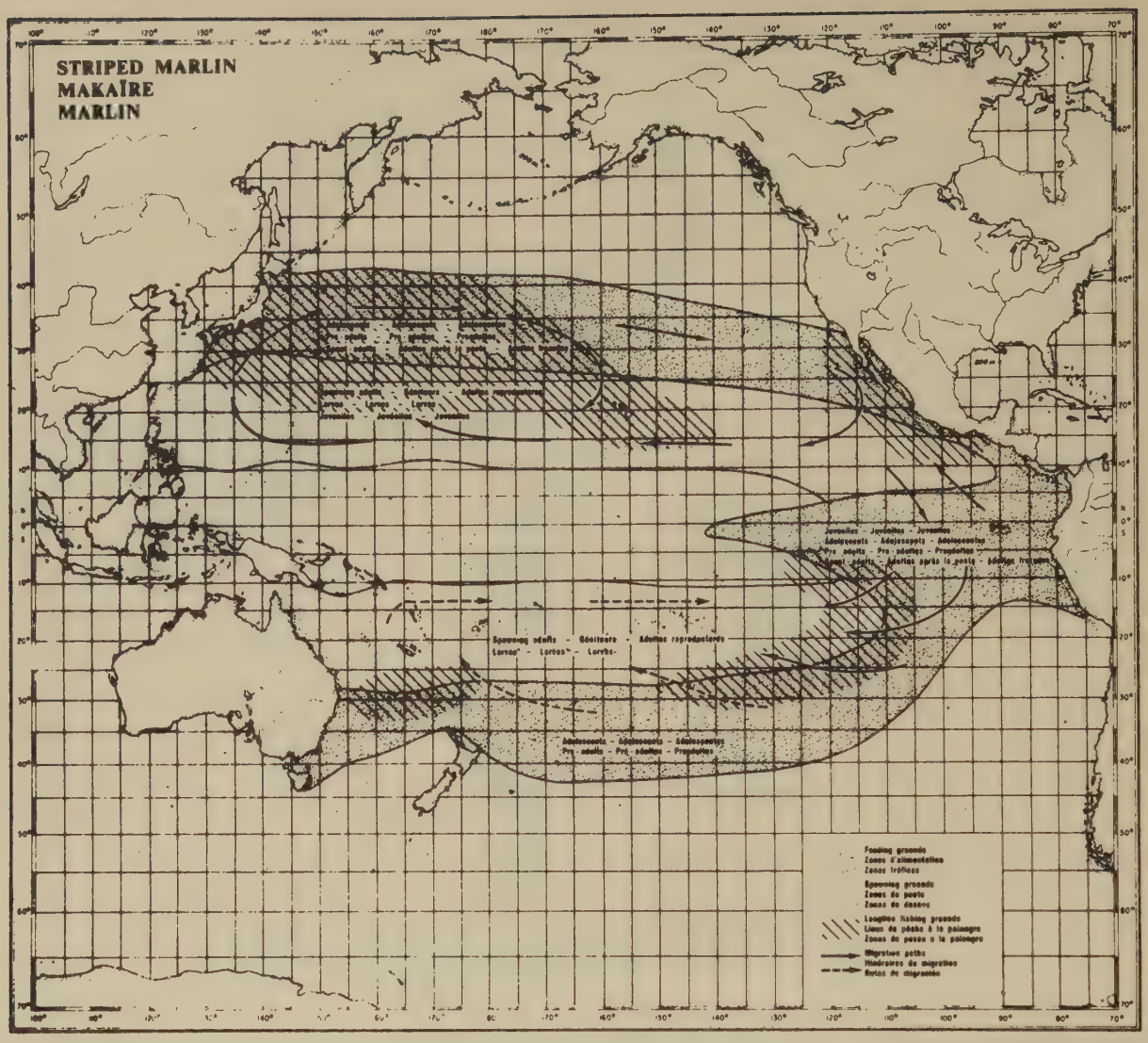


Figure 12 Striped marlin of the Pacific (from FAO, 1981d). Case of an international stock making transoceanic migrations whose migration and distribution pattern makes the problem of sharing the resource between potential operators extremely complex

to the villages located on it). The fact that in principle the national administrations have acquired new authority would also suggest that they can take more interest in the management of national shared stocks than they did in the past. It can be imagined that as they acquire experience the countries will have a better perception of the formulas which could facilitate the management of the stocks they share.

4.2.3 Fisheries management and regional cooperation

Through its influences on sharing of world fishery resources, the new Law of the Sea should profoundly alter the schemes for regional and sub-regional cooperation employed so far to deal with common problems of fishery exploitation and management. These changes are summarized in Appendix 1, stage by stage, from gathering raw data on fisheries to application of regulations and monitoring. To prepare this table we have chosen, as the most probable assumptions, the solutions which differ least from those most commonly accepted under the old system. Obviously the arrangements which could be adopted may differ, more or less markedly according to cases, from these general guidelines.

## 5. CONCLUSIONS

The new Law of the Sea, which has now been accepted in principle, can be interpreted as the first successful attempt to share world fishery resources between countries. The increasing scarcity of as yet partly exploited and easily valorized stocks played a large part in this development. With a total of 75 million t in 1979, the present world production probably represents three-quarters of what fishery resources could produce in the present economic and technological context (FAO, 1979a and 1981). Even so, this prospect has already been reduced due to delays in setting up appropriate management schemes in the most heavily exploited fisheries and by the increase of the relative cost of energy.

The drop, starting in 1972, of the rate of expansion of world production from an average figure of about 6.5 percent per year to an average percentage of the order of one percent shows that, in global terms, the period of abundance has now been passed. The limited character of the resources is not the only factor to have become a reality. Other limiting factors have also become obvious or better appreciated, particularly population pressure and the low mobility in the artisanal fisheries of a number of developing countries (Panayotou, 1982), the cost of energy or the slowness of the progress achieved in transfers of technology and gains of efficiency in the fisheries of various developing countries (Troadec, in preparation).

The impopularity of political decisions changing the distribution of profits, the technical and administrative complexities of management (especially those resulting from the apparent discrepancy between its macro and microscopic aspects), and the coercive aspects of the application of regulations explain why there are some who doubt its usefulness. However, the benefits which can be expected from management certainly outweigh those of development. The gross economic value of the potential still to be developed in the present technical and economic context is small overall[1/] compared to that of the catches obtained previously. The difference is even more marked when we compare net profits. In fact, the stocks to be developed add, to a lower average market value, fishing costs which are higher on the average because they are more dispersed in the sea. By comparison, the net profits which can be derived from better management of the existing fisheries are several times higher. The full realization of fishery potentialities therefore depends on management. The acuteness of the conflicts which are arising in the fisheries of a number of countries (depressed situation of certain artisanal fisheries in the developing countries, conflicts between artisanal and commercial fishing, etc.) make the problem even more urgent.

The authority the countries have now acquired makes it possible for them to go beyond the simple conservation of resources to which management was confined under the old system. The countries can now consider ways to reduce the considerable economic and social losses which go with full access to resources and the resulting excessive competition, and can work to improve the distribution of the benefits thus obtained between the different components of their societies.

This will probably involve considerable changes in management practices. The system of catch quotas, both global and national, commonly used in the international fisheries should be replaced by other more complete methods (limitation of total catch capacities through issue of fishing licences and control over gains of efficiency, direct allocation to fishermen of individual sections of stocks which are only slightly mobile or of individual catch quotas - for stable stocks whose catches can be controlled). In the selection of these methods and their application special attention should be paid to obtaining the direct participation of fishermen in the management of the fisheries which provide their livelihood.

Such participation depends on creating sufficient economic incentives to reduce excessive competition. To achieve this it is advisable that the allocation of resources should go beyond the network established by the EEZ and also be applied inside national sectors. Such

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1/ Obviously there are major differences in the respective prospects of different regions

measures as the assignment of sections of stocks, exclusive fishing rights in determined areas, or catch quotas to individuals or to specific fishermen's communities are undoubtedly limited in application. Nevertheless, they constitute a highly promising strategy to offset the harmful consequences of the free exploitation of resources. This is one of the basic principles of the regulatory system of the Japanese coastal fisheries, and has undoubtedly contributed to its success even if it is still far from perfect (Herrington, 1971). In line with this reasoning, it may be worthwhile to examine, among the various traditional customary rights, the systems which could be usefully revised and legalized. Indeed many traditional societies - even in technically advanced countries - have developed over the centuries very useful solutions to the difficult problem of control over fishery and the distribution of the fish resource among fishermen (Cordell, 1981); these are schemes whose advantages modern fishery science and administration, being more concerned with that aspect of the problem which is ultimately specific to the time and space scale of international fisheries, have often overlooked.

By delegating to fishermen a share (which varies according to the characteristics of the stocks, their fishing and the legal system of the fisheries) of the responsibility for the application of regulations, one would at the same time substantially reduce the cost and complexity of the tasks of monitoring and control. This is an acute need, especially in the developing countries whose administrative capacities are still small.

Unfortunately, the mobility of resources which characterizes sea fisheries limits these prospects. Even if in many cases one could reduce the size of the exploitation units to which specific resources can be assigned, a large part of the stocks will always have to be exploited jointly. The rationalization of their fishery will therefore depend on the possibilities of obtaining a consensus and exercising a central authority.

In many developing countries the traditional fishermen's communities need special attention.

The fact that their income has remained lower than that of other comparable socio-professional categories is due, rather than to lack of management to their scarce mobility, which itself is due, among other things, to their high specialization. In order to correct these disparities and involve the fishermen in management (which is the condition of progress in this sector) the State could envisage giving up part of the income from the resource for their benefit with the aim of increasing their mobility through improvement of their income.

To develop their fisheries, countries also have the possibility of using control of fishing, and particularly that of catch capacities and their distribution among the various national fisheries, as the foremost tool of development. Bearing in mind the dynamic of fisheries which encourages both present and potential participants to invest when and as long as they obtain net profits, one can imagine that the national administrations and both the national and international development agencies have attached too much importance in the past to the direct promotion of investments (particularly in the production sector) and not enough to the improvement and control of the environment and the conditions in which each fishery operates (Troadec, in preparation). In this respect it is significant that the establishment of a system for licensing vessels and controlling fishing capacities of fisheries which are still only partly developed (Japanese deep sea fisheries, Kasahara, 1964; Western Australia shrimp fishery, Meany, 1978) should be cited as a major contributing factor of their expansion (through the guarantees of stability and security which the control plan offered the fishermen and shipowners). The same dynamic could be used to promote the development of as yet little exploited stocks. The administration could offer potential investors a limited number of fishing licences so as to assure such investors that newcomers will not come in too large numbers to further reduce the profits they can expect from their development effort and the risks they have agreed to take.

In fact, development and management should be considered simultaneously and should stem from a long-term view of the improvement of national fisheries considered as a whole. The advantage of a global approach covering all the components (stocks, fleets, fishermen) constituting fisheries within sufficiently large management units appears, at the operational level, to be a condition of progress. Otherwise, it will be difficult to offset the losses of efficiency which have been common with past approaches that are too fragmen-

tary or too specific in view of the very great difficulties raised by the application of regulations. To formulate more effective development and management strategies it is necessary to start from a global balance (even though it may be cursory) of national fisheries. Such evaluations are important in order to accurately assess the respective prospects of the different fisheries, the options their development offers in the context of the main objectives of national economic development, the conflicts between objectives and the possibilities of reducing them, and the major constraints. These evaluations could subsequently consider the following aspects:

(a) inventories of fisheries and their structure: fleets, fishermen, utilization of their production, markets, etc.;

(b) the links between these elements, so as to identify the fisheries which could be administered separately, their relationships and the connections between groups of fishermen and the various resources within each fishery, and what possibilities the fishermen have of changing them;

(c) clarification of objectives and reduction of the possible conflicts between them;

(d) analysis of development and management options, i.e., of the constraints and risks attached to them;

(e) the formulation of a global fisheries policy (Doucet, Pearse and Troadec, 1981).

When this framework will have been created, a plan of actions (investments, management schemes, training, etc.) can be set up efficiently and implemented. Obtaining a consensus of the parties concerned at the different national management plans will give national administrations the reference frames without which it could be extremely difficult for them to adopt and apply the decisions necessary to the sound utilization of national fishery resources. In view of the tendency toward over-capitalization and over-exploitation to which fisheries are subject due to the common nature of the limited character of resources and the difficulties of regulating access to them, without such an overall view and such a consensus the evolution of national fisheries will probably continue to be difficult to control.

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APPENDIX

Stages in Fishery Management and Requirements in the Field of Regional Cooperation

| Stages | Responsibility - country participation | Notes |
|---|---|---|
| A. Evaluation of fisheries | | |
| A.1 Data gathering | National | Regional organization possible; however current practice is to give this responsibility to the countries and to provide them, when necessary, with technical support or regional fishery organization. |
| A.2 Compilation and redistribution of data of regional interest | Regional (all coastal countries, eventually with the non-coastal countries operating in the region; regional harmonization for purpose of compatibility) | Different arrangements to be foreseen, depending on the regions, with regard to participation of non-coastal countries. The latter may, as in the past, report the statistics directly to the regional organization, which will then transmit to the coastal countries those statistics concerning them, or report to the coastal countries in whose EEZ they operate, who will then transmit to the regional organization. The formula to be selected will partly depend on the capacities of the coastal countries to process the data. |
| A.3 Study of distribution and migration patterns | Sub-regional (all coastal countries directly involved) or regional, with or without the participation of non-coastal countries that may have accumulated data and expertise on the matter | Joint analysis by the coastal countries directly involved with this type of information has become essential under the new regime in order to develop a mutual understanding of the data that are available on this subject (as has always been the case for the assessment of international stocks; A.4); such common understanding was of little importance under the old regime, when each country could fish for its quota anywhere within the area open to the distribution of international stocks. Participation may be limited to research workers from only the single countries concerned with a given stock (sub-regional participation) or open to research workers from all countries in a region (regional participation), if the countries are sensitive to the |

| Stages | Responsibility - country participation | Notes |
|---|---|---|
| | | similarities of the resources or are faced with a shortage of expertise. The participation of research workers from non-coastal countries will depend on the information they have accumulated and the activity of their fleets in the region, as well as the scientific capabilities of the coastal countries; in regions where these are still modest the participation of foreign research workers in the region is more likely. |
| A.4 Stock assessment (current state of fishing and foreseeable consequences of different levels of fishing) | Sub-regional or regional (see above) | The same remarks as for A.3 (similar, parallel function) |
| A.5 Strategies for the development and management of fisheries (technical aspects) | Regional, with or without participation of non-coastal fishing countries | Supplementary stage to integrate the social, economic and biological aspects of development and management of fisheries in the region and to compare the various options and their implications as regards development and management. The similarity of problems would suggest a regional research. |
| A.6 Orientation of fisheries research | Regional or world-wide | As noted above, the participation of research workers of countries foreign to the region and its extent will depend, among other things, on the expertise available locally. Likewise the major research problems of the fisheries in the region may be discussed at the regional or, possibly, at the world level. |
| B. Negotiations of sharing agreements[a/] (shared stocks) | | This stage could be handled with or by other administrations (particularly the foreign affairs branch), since matters concerning distribution of national wealth are neither directly nor exclusively the responsibility of fishery administrations. |

a/ The distinction between the evaluation function and that of negotiation does not mean that the latter should start after the former. Negotiations should be started when their potential usefulness becomes obvious, regardless of what data may be available

| Stages | Responsibility - country participation | Notes |
|---|---|---|
| B.1 Fishing strategy (harmonization of objectives and search for a common fishing rate) | Sub-regional (restricted to those countries having the stock in question) | The harmonization of objectives will be easier to achieve between those countries that have similar levels of economic development and whose fisheries are characterized by similar prospects and difficulties (e.g., the countries of the Northern zone of CECAF). Such research work will be difficult when the opposite holds true. In the latter case, objectives for fisheries development and management are liable to diverge fundamentally from one country to another; e.g., the objectives of Mexico and the USA concerning the development of their anchovy stock, Section 4.2.1. |
| B.2 Distribution of the resource (as a percentage of the total, expressed either in catch capacity or in fishing effort) | Sub-regional | Probably only those countries who are the owners of each stock will participate in these negotiations, which may or may not be held within the framework of the regional organization. |
| C. Formulation of national fishing plans | | See FAO, 1979. |
| C.1 Establishment of national objectives for development of national fishing resources | National | |
| C.2 Distribution of national fishery resources among the various national fisheries (including possible participation of foreign fleets) | National | |
| D. Exploitation | | |
| D.1 Eventual signature of reciprocal fishing agreements, authorizing the fleets to operate throughout the zones within the jurisdiction of the different countries involved, between countries sharing the same resource | Sub-regional and *ad hoc* (among countries sharing the same resources) | Justification of such agreements will depend on the advantages, particularly in increased yields and in the full utilization of catch capacities, expected from the assignment, to the various national fleets of countries who are co-owners of the stock, of the right to fish over a wider area of the stock's distribution. |

| Stages | Responsibility - country participation | Notes |
|---|---|---|
| E. Follow-up, implementation and monitoring | | |
| E.1 Follow-up on the state of fisheries | National, sub-regional and/or regional | The working groups organized under items A.2 and A.4 above could again supply the best mechanism to reveal distortions and omissions in the reporting of data. |
| E.2 Monitoring systems (coast guards, aeroplanes) | Purely national or with the possibility of sub-regional or regional cooperation | The solution adopted will depend on the size of the task involved (e.g., monitoring of tuna fishing) and the possibilities for raising efficiency and reducing costs via cooperation (exchanges of information) and the pooling of logistic resources. |
| E.3 Follow-up of implementation of regulations | National sub-regional (among co-owning countries of the same stocks) | A good system for sharing information on the way each country applies the regulations is essential in order to get the fishermen of the different countries to agree to mutually acceptable restraints; agreements on the exchange of personnel to check on the quality of the inspection plans in the various ports, the possibility of establishing joint inspection programmes at sea on the fishing vessels; the advantage of reciprocal fishing agreements for mutual observation of the fishing fleets. |
| E.4 Legal action | Purely national | |

N.B. Gulland's work (1981) also contains consideration on the need for cooperation in evaluation and management of fisheries.

For a more detailed treatment of matters under stage B - Negotiation of sharing agreements and C - Formulation of national fishing plans - readers can refer to the report of the Conference on Management of Stocks in the Statistical Division Sahara and Cape Verde, Dakar (Senegal), June 1979 (FAO/CECAF, 1979). Likewise, for questions of follow-up, control and monitoring (stage E), see the report of the FAO Consultation which was held on this subject in Rome from 27 to 30 April 1981 (FAO, Norway Cooperative Programme, 1981).

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